

QUANTIFICATION OF LIBBY RESERVOIR LEVELS NEEDED  
TO MAINTAIN OR ENHANCE RESERVOIR FISHERIES

METHODS AND DATA SUMMARY, 1983-1987

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## EXECUTIVE SUMMARY

The Libby Reservoir study is part of the Northwest Power Planning Council's resident fish and wildlife program. The program was mandated by the Northwest Power Planning Act of 1980 and is responsible for mitigating damages to the fish and wildlife resources caused by hydroelectric development in the Columbia River Basin. The major goal of this and the Hungry Horse Reservoir study is to quantify seasonal water levels needed to maintain or enhance the reservoir fishery. This study began in May, 1983, and the initial phase was completed in July, 1988.

The three study areas of Libby Reservoir are affected differently by dam operation and reservoir morphology. Relative changes in water volume and surface area are greatest in the Canada and Rexford areas and least in the Tenmile area. By analyzing surface elevations, it is apparent that the reservoir was drafted less rapidly during fall prior to 1984. Since 1984, a greater percent of the annual drawdown has been shifted to the fall prior to snowpack forecasts, leading to reduced flexibility in drawdown management.

Oxygen and pH were not limiting for trout or salmon during the study period. Reservoir morphology, hydraulics and dam operation affect fish distribution by influencing temperature. Optimum growth conditions for kokanee existed from May to November in the Tenmile and Rexford areas and May through October in the Canada area.

The highest areal primary productivity rates were in the Tenmile and Border stations in July. Light, turbidity and temperature are the most important factors affecting primary production in the reservoir. A weak thermal structure, caused by rapid replacement of water within the reservoir, turbid spring inflows, and seasonal variations in incident solar radiation influence production.

Densities of benthic invertebrates were negatively affected by drawdown. Density significantly decreased from the permanently wetted zone to the frequently dewatered zone. The shallow and mid zones increased in density as water levels were raised. Dipterans were the predominant benthic invertebrate in all zones, but percentages decreased with depth in the reservoir.

The nearshore zone generally had greater densities and biomasses of surface macroinvertebrates than did the limnetic zone. The difference was not statistically significant due to high variances caused by patchy distribution. Lower relative densities of terrestrial insects in the Rexford area were attributed to large expanses of barren ground between the shoreline vegetation and water that impeded terrestrial transport. Higher relative aquatic invertebrate densities in the Rexford area were attributed to larger areas of productive shallow water and substrate. Peaks in abundance were seasonal and related to emergence patterns of insect types.

Emergence of dipterans peaked from April through June. Emergence as no./m<sup>2</sup>/wk was greatest in the occasionally dewatered zone, followed by the frequently dewatered zone and the permanently wetted zone. High emergence in the shallow zone in May could be due to transport of emerging pupae across zonal boundaries by wind or water currents, recolonization by larvae, or rapid emergence after reflooding the shallow zone during reservoir refill. Higher densities of emerging insects in the mid and shallow depths as compared to relatively low densities of benthic insects may be explained by recolonization, sampling bias, or greater productivity in shallow and mid zones than in deep zones.

The copepods Diaptomus and Cyclops made up the majority of the zooplankton community. Daphnia abundances were generally greatest in the Canada area and may be related to earlier summer warmup, decreased vertebrate predation and greater nutrient input than in the other areas. Densities of Daphnia < 1.5 mm were greatest and densities of Daphnia > 1.5 mm were least during years of high kokanee densities, suggesting a size-selective feeding behavior for kokanee. Greatest densities for all zooplankton species were found in the upper none meters of water during spring and summer months, and maybe a response by the planktons to the shallow euphotic zone caused by turbid spring inflows.

Floating and sinking gill net trend sampling since 1975 indicates an increase in kokanee, peamouth, yellow perch, and northern squawfish populations. We observed a trend for decreased abundance in Oncorhynchus trout species, mountain whitefish, and reidside shiner, whereas the abundances of largescale and longnose suckers, bull trout, and ling appeared to remain constant. Vertical gill net catches in the lower two study areas of the reservoir were dominated by kokanee; peamouth were dominant in the Canada area.

Hydroacoustic estimation of kokanee densities suggest a cyclic trend beginning in 1981 of a strong year class followed by two weaker year classes. This fluctuation in numbers is moderating but remains evident in the sampling. Densities of kokanee during August were generally greatest at Peck Gulch and least in the Canada area.

Analysis of otoliths and scales indicated that size-at-age for Oncorhynchus trout species was related to time of emigration from their natal streams. Initial growth advantage realized by younger migrants was negated by the fourth year in the reservoir. Growth of kokanee was slowest when population densities of the previous year's kokanee were high. Greatest growth of kokanee corresponded with blooms of Daphnia. Bull trout exhibited greatest growth in the first year of reservoir life. Results differ from other studies and are possibly related to predation on kokanee, chub, sucker, trout or some other available food source.

Daphnia were the most important food source for kokanee, mountain whitefish, peamouth chubs and largescale suckers during all seasons. Daphnia were also important in the diet of two size

classes of trout (< 330 mm and > 330 mm) in the winter and to a lesser extent in the fall. Competition between these species for Daphnia probably did not occur due to differences in size selection of Daphnia, habitat utilization, relative abundance, and consumption of alternative food items. Both bull trout and burbot fed predominantly on fish, although the majority of biomass ingested by bull trout came from kokanee, largescale suckers and trout species, while largescale suckers alone accounted for the majority of biomass consumed by burbot. Further analysis will be needed if recently introduced Kamloops rainbow trout become established in the reservoir.

Catches of migratory trout in Young Creek between 1970 and 1987 reflect the effects of management activities, angler harvest, and changes in the reservoir fish community over the period. Captures increased following the removal of passage barriers, and increased again following the imprint planting of cutthroat fry in Young Creek. With the cessation of planting in 1976 and the decrease of cutthroat in the reservoir, captures in Young Creek have continually declined.

## INTRODUCTION

Libby Reservoir was created under an International Columbia River Treaty between the United States and Canada for cooperative water development of the Columbia River Basin (Columbia River Treaty 1964). The authorized purpose of the dam is to provide power (91.5%), flood control (8.3%), and navigation and other benefits (0.2%).

The Pacific Northwest Power Act of 1980 recognized possible conflicts stemming from hydroelectric projects in the northwest and directed Bonneville Power Administration to "protect, mitigate, and enhance fish and wildlife to the extent affected by the development and operation of any hydroelectric project of the Columbia River and its tributaries..." (4(h)(10)(A)). Under the Act, the Northwest Power Planning Council was created and recommendations for a comprehensive fish and wildlife program were solicited from the region's federal, state, and tribal fish and wildlife agencies. Among Montana's recommendations was the proposal that research be initiated to quantify acceptable seasonal minimum pool elevations to maintain or enhance the existing fisheries (Graham et al. 1982).

Reservoirs are best regarded as a distinct type of freshwater ecosystem, differing from both streams and lakes (Baxter 1977). Reservoir water level management is considered to be an important tool for fisheries management (Willis 1986). Acknowledgement of the value of water level management to maintain desirable reservoir fisheries has resulted in a vast amount of research literature (see bibliographies of Triplett et al. 1980, Ploskey 1982). However, ecological approaches to understanding and predicting the potential impacts of hydroelectric facilities are relatively new (Magnuson 1979).

An inter-disciplinary team of experts met in 1980 to discuss incorporating ecological issues in basin-level hydropower planning (Hildebrand and Goss 1981). They concluded that the capability to predict water-level changes was adequate but modeling of biological effects was inadequate. In a national survey of reservoir biologists to identify reservoir fishery research needs, better knowledge of water quality/fish interactions and the ability to predict impacts of reservoir drawdowns and/or water level fluctuations were considered highest priorities for necessary information (Hall 1985). Long-term data replicating several management and recruitment events are needed to develop these predictive models (Ploskey 1986).

Research began in May 1983 to determine how operations of Libby dam impact the reservoir fishery and to suggest ways to lessen these impacts. This study is unique in that it was designed to accomplish its goal through detailed information gathering on every trophic level in the reservoir system and integration of this information into a quantitative computer model. The specific study objectives are to:

- 1) Quantify available reservoir habitat,
- 2) Determine abundance, growth and distribution of fish within the reservoir and potential recruitment of salmonids from Libby Reservoir tributaries within the united states,
- 3) Determine abundance and availability of food organisms for fish in the reservoir,
- 4) Quantify fish use of available food items,
- 5) Develop relationships between reservoir drawdown and reservoir habitat for fish and fish food organisms, and
- 6) Estimate impacts of reservoir operation on the reservoir fishery.

## DESCRIPTION OF STUDY AREA

Libby Reservoir (Lake Koocanusa) was formed by impoundment of the Kootenai River in March 1972. Libby Dam is located in Lincoln County, northwest Montana, approximately 27 km (17 mi) upstream from the town of Libby (Figure 1). The Montana portion of the reservoir is bordered mainly by the Kootenai National Forest. The majority of the private property is located near the town of Rexford.

The land adjoining the Canadian portion of the reservoir is principally owned by private citizens. A notable exception to this is the Kikomun Provincial Park which is located on the east bank of the reservoir, 10 miles south of the town of Wardner, British Columbia.

## WATER QUALITY

The Kootenai River is the second largest tributary of the Columbia River, with an average annual discharge of  $868 \text{ m}^3/\text{s}$  (30,650 cfs). Libby Reservoir and its tributaries receive runoff from 47 percent of the Kootenai River drainage basin. The reservoir has an annual average inflow of 10,615 cfs and three Canadian rivers, the Kootenai, Elk, and Bull, supply 87 percent of the inflow (Woods 1982).

Cranbrook, Fernie, and Kimberly, in British Columbia, and Eureka in Montana have contributed the major municipal point sources of water pollution. Industrial point source pollution has occurred from the Sullivan (Cominco Ltd.) lead/zinc mine and its ore concentrator on Mark Creek, Crestbrook Forest Industries Ltd. bleached kraft pulp mill at Skookumchuk, and a Cominco Ltd. phosphate fertilizer plant, also on Mark Creek near Kimberly.

By 1981, these industries had taken major steps toward pollution abatement with the installation of wastewater purifying and recycling equipment. Also, after September 1987, Cominco Ltd. closed the phosphate fertilizer plant; it is believed this will significantly reduce phosphate loadings to the St. Mary River and ultimately the Kootenai.

The drainage basin is located within the Northern Rocky Mountain physiographic province, which is characterized by north to northwest trending mountain ranges separated by straight valleys parallel to the ranges (Woods and Falter 1982). These mountains are composed of folded and faulted crystal blocks of metamorphosed sedimentary rocks of the Precambrian Belt Series.

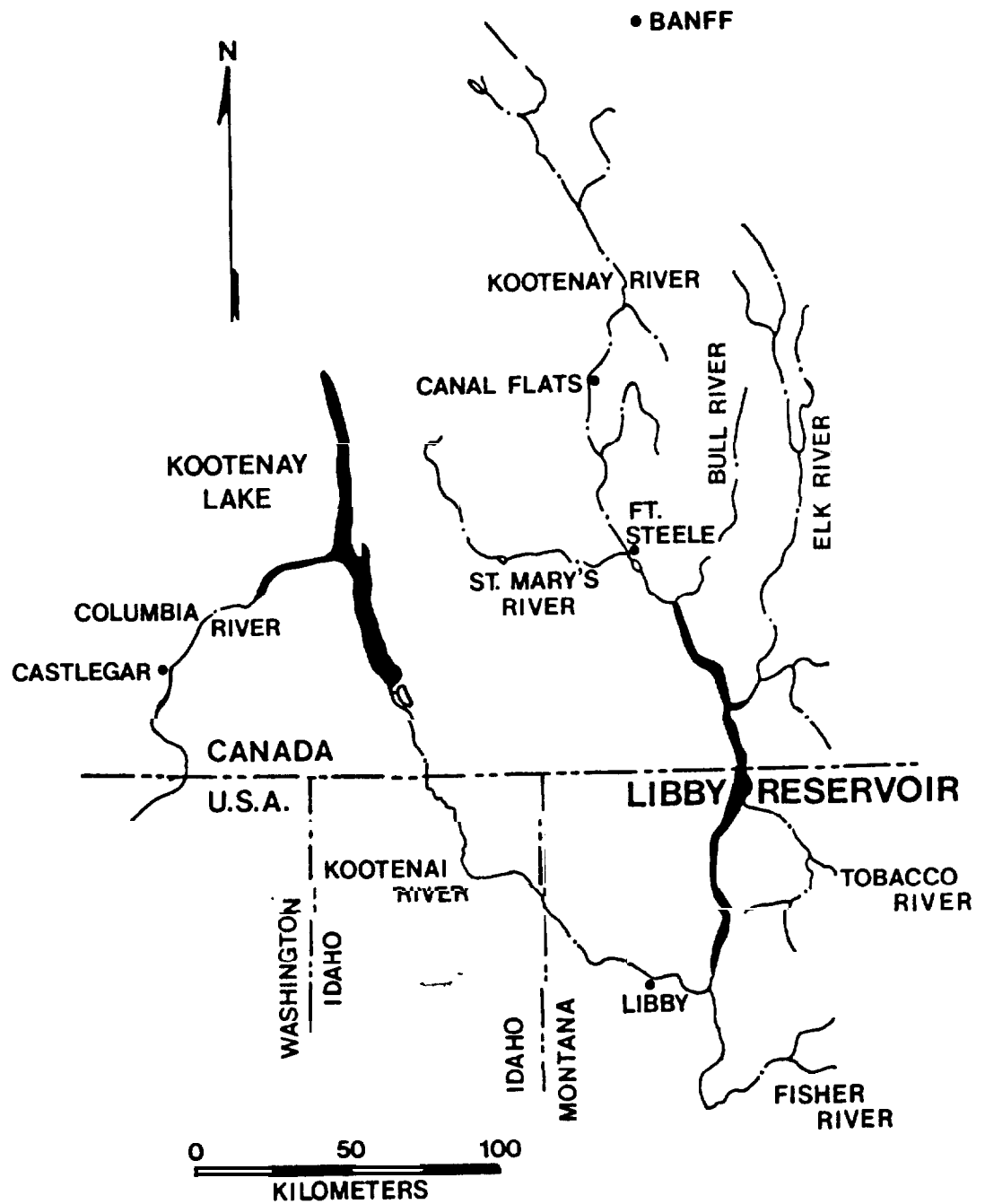


Figure 1. Map of the Kootenai River basin showing the location of Libby Reservoir (Lake Kootenai).

## MORPHOLOGY

At full pool, the reservoir extends 145 km northward, with 68 km of its length located in British Columbia. Maximum volume and surface area are  $7.24 \text{ km}^3$  and  $188 \text{ km}^2$ , respectively (Table 1).

Libby Dam is a 113-m (370-ft) high concrete gravity structure with three types of outlets: three sluiceways, five operational penstock intakes (eight possible), and a gated spillway. A selective withdrawal system was installed at Libby Dam to allow for withdrawal of water from the reservoir ranging from the penstock invert (elevation 677 m or 2,222 ft) to within about 6 m (20 ft) of the surface at full pool (Bonde and Bush 1982). This system became operational in the spring of 1978. The dam crest is 931m long (3,055 ft) and the widths at the crest and base are 16 m (54 ft) and 94 m (310 ft), respectively.

## RESERVOIR OPERATION

Libby Reservoir is a headwater storage project operated by the Army Corps of Engineers (ACOE) as an integral part of the Columbia River Basin hydroelectric network. Reservoir elevations are managed primarily for power and flood control purposes (Storm et al. 1982). The ACOE operates Libby Reservoir to reach full pool in July, begins drafting the reservoir in September, reaches a minimum pool elevation in March, and begins refilling the reservoir in spring.

## FISH SPECIES

Seventeen species of fish are present in the impoundment (Table 2). Libby Reservoir currently supports an important fishery for kokanee (Oncorhynchus nerka), rainbow trout (Oncorhynchus mykiss) and westslope cutthroat (Oncorhynchus clarki) with annual fishing pressure over 500,000 hours (Chisholm and Hamlin 1987). Burbot (Lota lota) and bull trout (Salvelinus confluentus) are also important game fish, providing a significant fishery during the winter and spring months.

Table 1. Morphometric data for Libby Reservoir.

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Surface elevation	
maximum pool	749.5 m (2,459 ft)
minimum operational pool	697.1 m (2,287 ft)
minimum pool(dead storage)	671.2 m (2,222 ft)
Area	
maximum pool	188 sq. km (46,500 acres)
minimum operational pool	58.6 sq. km (14,487 acres)
Volume	
maximum pool	7.24 km <sup>3</sup> (5,869,400 acre-ft)
minimum operational pool	1.10 km <sup>3</sup> (890,000 acre-ft)
Maximum length	145 km (90 mi)
Maximum depth	107 m (350 ft)
Mean depth	38 m (126 ft)
Shoreline length	360 km (224 mi)
Shoreline development	7.4 km (4.6 mi)
Storage ratio	0.68 yr
Drainage area	23,271 sq. km (8,985 sq. mi)
Drainage area:surface area	124:1
Average annual discharge	
pre-dam record (1911-1972)	12,170 cfs (Storm et al. 1982)
	or 11,774 cfs (our data)
post-dam record (1974-1986)	10,615 cfs

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Table 2. Current relative abundance (A=abundant, C=common, R=rare) and abundance trend from 1975 to 1987 (I=increasing, S=stable, D=decreasing, U=unknown) of fish species present in Libby Reservoir.

Common Name	Scientific name	Relative abundance	Abundance trend
<u>Game fish species</u>			
Westslope cutthroat trout	<u>Oncorhynchus clarki lewisi</u>	C	D
Rainbow trout	<u>Oncorhynchus mykiss</u>	A	D
Bull trout	<u>Salvelinus confluentus</u>	C	S
Brook trout	<u>Salvelinus fontinalis</u>	R	U
Lake trout	<u>Salvelinus namaycush</u>	R	U
Kokanee salmon	<u>Oncorhynchus nerka</u>	A	I
Mountainwhitefish	<u>Prosopium williamsoni</u>	C	D
Burbot	<u>Lota lota</u>	C	I
Largemouth bass	<u>Micropterus salmoides</u>	R	U
White sturgeon	<u>Acipenser transmontanus</u>	R	D <sup>a/</sup>
<u>Nongame fish species</u>			
Pumpkinseed	<u>Lepomis gibbosus</u>	R	U
Yellow perch	<u>Perca flavescens</u>	C	I
Redside shiner	<u>Richardsonius balteatus</u>	R	D
Peamouth	<u>Mylocheilus caurinus</u>	A	I
Northern squawfish	<u>Ptychocheilus oregonensis</u>	A	I
Largescale sucker	<u>Catostomus macrocheilus</u>	A	S
Longnose sucker	<u>Catostomus catostomus</u>	C	S

<sup>a/</sup> Five white sturgeon were relocated from below Libby Dam to the reservoir. At least one of these fish moved upriver out of the reservoir and two were reported caught by anglers.

## RESERVOIR HABITAT

### Methods

Libby Reservoir has been divided into three areas for study purposes by the Montana Department of Fish, Wildlife and Parks (Huston et al. 1984, Chisholm and Fraley 1986). Segregation into three geographic areas was based on reservoir morphometry, effects of reservoir drawdown, and political boundaries (Figure 2).

The 'nearshore' or littoral zone was defined as that portion of the reservoir within 100 m of the shoreline. The remaining area of the reservoir was designated as the limnetic zone.

Contour maps of the area impounded by Libby Dam [(USACOE, File Number E53-1-154, Sheets 1-37, 1972 and British Columbia Ministry of the Environment, Drawings M-249-C, Sheets 1-63, 1969)] were digitized to allow for computer access and storage. Each ten foot contour interval was entered for all reservoir maps from full pool elevation (2,459 ft above mean sea level) to 2,190 ft, and 30 foot contours were entered from 2,190 ft to the reservoir bottom. Water surface area and volume were calculated using equations generated from this data which mathematically defined a cubic spline relationship between elevation and the variables.

### Results and Discussion

Reservoir operation differentially affects the three study areas of the reservoir-- a function of their basic morphology and proximity to the dam (Figure 3). Annual vertical fluctuations of up to 52.4 m (172 ft) occur, reducing total volume nearly 85 percent and mean depth by 51 percent. Drawdown to the minimum operational pool reduces the length of reservoir by 53 percent (to 67.6 km), the volume by 85 percent (to  $1.08 \text{ km}^3$ ), and the surface area by 69 percent (to  $58.6 \text{ km}^2$ ). Relative changes in water volume and surface area are greatest in the Canada and Rexford areas and least in the Tenmile area. At full pool, the Canada area comprises 38 percent of the total surface area, and a 100 - ft drawdown reduces the Canada area to less than 12 percent of the total (Appendix A, Table A1). Conversely, the relative percent of total surface area in the Rexford and Tenmile areas increase from comprising 24.7 and 37.2 percent of the total at full pool to 31.9 and 56.5 percent at a 100-ft drawdown, respectively (Appendix A, Table A1). A graph of the relationship of reservoir elevation to surface area and volume is provided in Appendix A, Figures A1 and A2. The mean depth of 38.1 m at full pool is reduced to 8.6 m at 172-ft drawdown.

Reservoir drawdown has averaged 118 ft since 1974 (Table 3). Full pool (2,459 ft above msl) was first reached in July 1974 and the reservoir has attained that elevation 10 of the 14 years since. Deepest drafts occurred in 1974 (153 ft), 1975 (172 ft), and 1976 (152 ft), and in two of these years (1974 and 1976) the

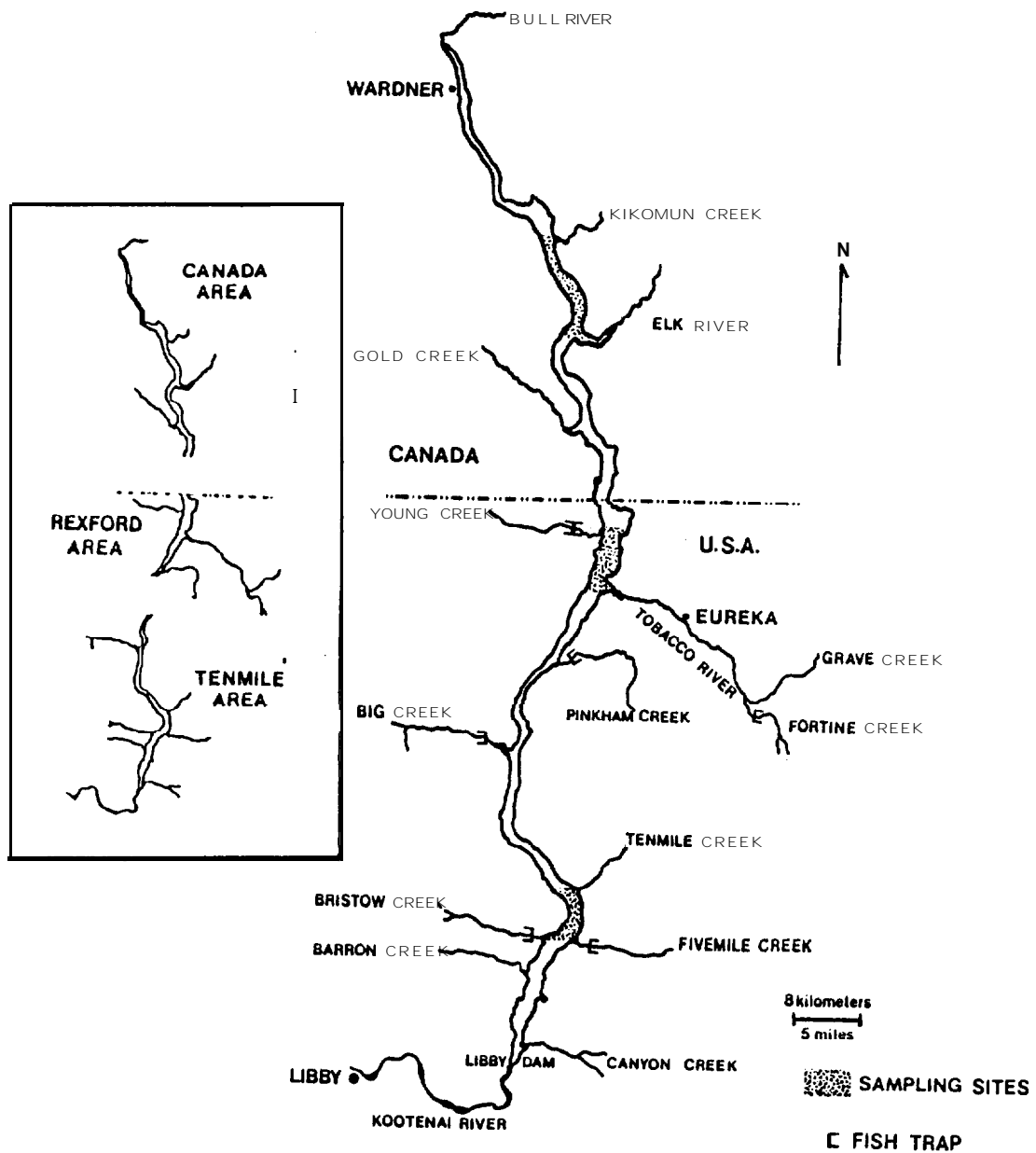


Figure 2. Sampling stations, fish trap locations, and principal tributaries of Libby Reservoir. Inset delineates geographic study areas.

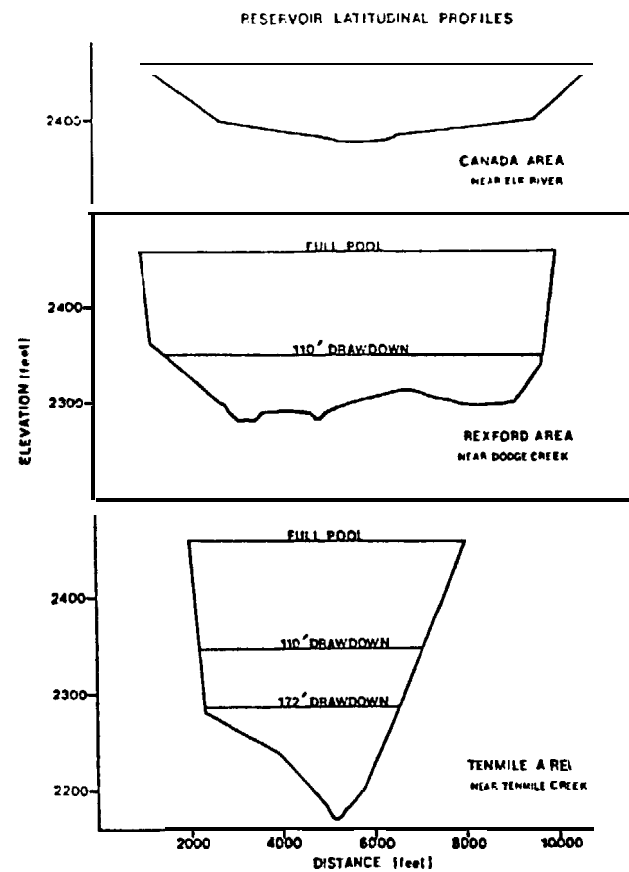
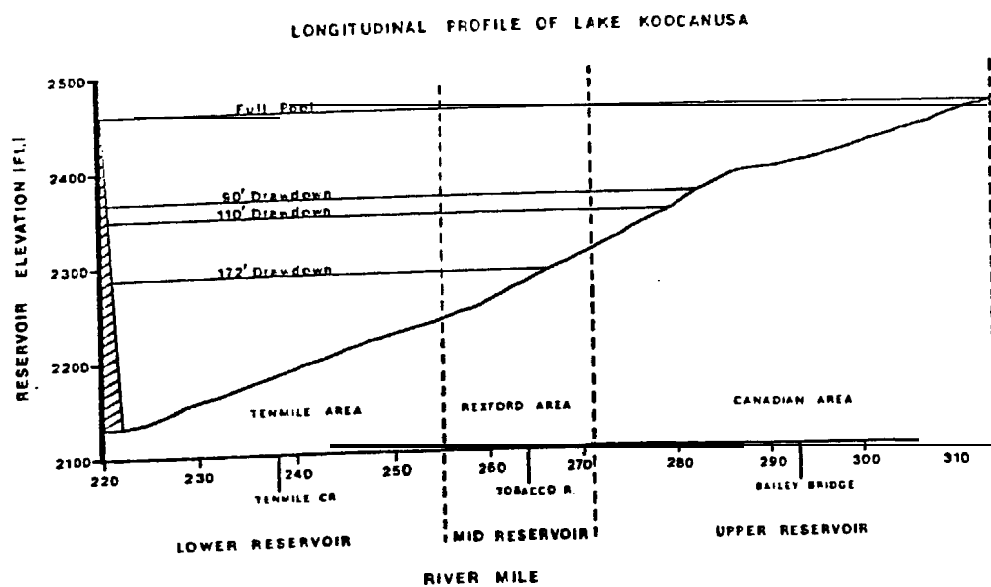


Figure 3. Longitudinal and latitudinal profiles of Libby Reservoir showing important reference pool elevations.

Table 3. Lake-fill time (yrs.), hydraulic-residence time (yrs.), maximum drawdown, number of days held at full pool, and maximum reservoir elevation for Libby Reservoir by year from 1972 through 1987.

Year	Lake-fill time (yrs)				Hydraulic-residence (yrs)				Maximum		No. days at full pool	Max. pool elevation (ft)
	Annual	Monthly			Annual	Monthly			ft	m		
		Mean	Min.	Max.		Mean	Min.	Max.				
1972	0.14	0.17	0.04	0.52	0.14	0.14	0.02	0.37				
1973	0.22	0.40	0.10	0.88	0.33	0.49	0.11	1.29	230	70.3	0	2417
1974	0.28	0.61	0.09	1.28	0.29	0.33	0.13	0.67	153	46.6	66	2459
1975	0.37	0.63	0.11	1.13	0.41	0.78	0.10	2.66	172	52.4	0	2454
1976	0.38	0.71	0.13	1.54	0.38	0.55	0.13	1.56	152	46.2	53	2459
1977	0.64	0.93	0.26	1.64	0.50	0.59	0.24	1.42	100	30.5	0	2414
1978	0.43	0.75	0.18	1.33	0.48	0.63	0.24	1.28	129	39.3	26	2459
1979	0.66	1.08	0.22	1.78	0.62	0.97	0.22	2.08	95	28.9	0	2451
1980	0.52	0.94	0.17	1.47	0.58	0.78	0.29	2.07	106	32.3	34	2459
1981	0.33	0.89	0.12	1.77	0.41	0.59	0.23	1.29	110	33.5	51	2459
1982	0.46	0.84	0.11	1.53	0.46	0.49	0.24	0.89	117	35.7	56	2459
1983	0.50	0.81	0.13	1.96	0.51	0.61	0.22	1.57	111	33.8	44	2459
1984	0.61	1.02	0.16	1.78	0.56	0.74	0.25	1.53	89	27.1	17	2459
1985	0.55	0.86	0.13	1.36	0.54	0.80	0.19	1.96	117	35.7	0	2450
1986	0.47	0.71	0.16	1.13	0.47	0.64	0.21	1.38	105	32.0	43	2459
1987	1.07	0.62	0.16	1.77	0.63	0.85	0.35	1.96	101	30.8	26	2459
Average (post 1974)									118	36.0	41.6	
(all years)											29.7	

reservoir was refilled. The average time spent at full pool was over one month (41.6 d); this figure does not include those years where full pool was not reached. The mean elevation reached for a non-refill year (post 1974) was 2,442 ft above msl or 17 ft below full pool.

During the five years of this research project, the reservoir inflow equaled annual outflow volume from Libby Dam, except in 1985 when the reservoir did not refill. Maximum inflow occurred during May for all years from 1983 through 1987, whereas, in general maximum outflow occurred during November (Appendix A, Figures A3, A4). This annual pattern of inflow and outflow produced large fluctuations in reservoir surface elevation (Appendix A, Figure A5). Graphs of mean monthly outflow temperature and dam withdrawal elevation for 1983 through 1987 are also provided in Appendix A (Figures A6, A7). Withdrawal elevation was generally 60 to 70 ft below the surface elevation of the reservoir from May through November.

Management of fall outflows at Libby Reservoir has changed since 1984. By comparing year-end reservoir surface elevations before and after 1984, it is apparent that the reservoir is being drafted to a greater depth at an earlier time. Mean reservoir elevation for December 31 from 1973 to 1983 was 2,400.6 ft (standard deviation = 15.2) versus 2,389.8 ft (standard deviation=2.2) for the years 1984 to 1987. A one-tailed t-test confirmed that the later year elevations were statistically less than those prior to 1984 ( $t=1.78$ ,  $df=8.73$ ,  $p=0.034$ ). Within the operational limits of the reservoir (2,287 ft above msl), the additional 10-ft drawdown by December 31 represents a 13 percent reduction in available volume. Deeper draft before January is likely to lead to reduced flexibility in drawdown management, as these drafts are taking place before the first snowpack forecasts are issued on January 1 of each year. The resulting power is currently marketed as surplus firm power, which does not supplant the firm power commitments.

Lake-fill and hydraulic residence are expressions of the time it takes to refill a reservoir at a given inflow and how long the water stays in the reservoir at a given outflow, respectively. Lake-fill (or retention) times are expressed mathematically as volume (V) divided by inflow (I) and the expression for hydraulic residence is volume/outflow (V/O) (Woods and Falter 1982).

Straskraba (1973) considered lake-fill (retention) time to be a major key to understanding reservoir limnology. Retention time affects thermal structure (Straskraba 1973), water currents and nutrients, and therefore the degree of eutrophy (Dillon 1975) and primary production in a reservoir (Dickman 1969, Woods 1979, St. John et al. 1976).

Lake-fill times are greatest in Libby Reservoir in the late summer months (when inflow is smallest and volume is the largest) and minimum during runoff months (when inflow is large and reservoir volume is relatively small following fall and winter

drawdown). Hydraulic residence times in Libby Reservoir are greatest during the winter/spring refill or the summer months (when  $Q$  is small or  $V$  is approaching capacity, respectively). Minimum hydraulic residence times normally occur during the fall and winter months, when dam outflow is at its maximum and the volume has been reduced from drafting.

## **WATER QUALITY**

### **Methods**

A permanent sampling buoy was placed within each area (an established United States Geological Survey [USGS] buoy was used in the Ternmile area) where water quality and zooplankton sampling were conducted. In addition, eight to twelve transects were established between recognizable landmarks in each area. These transects were further subdivided into east, west, and mid reservoir stations for random sampling.

Vertical layers of the water column were defined using measurements of light penetration, water temperature, dissolved oxygen, pH, and conductivity (umhos/cm). A Protomatic photometer and a Martek Mark V digital water quality analyzer were used to measure the above variables. Sampling was conducted in each geographic area on a biweekly basis from May through October, and monthly from November through April unless dewatering of boat ramps or ice formation prohibited access (Table 4).

Martek sampling was done using methods followed by the USGS (Greenson et al. 1977). Water quality measurements were taken at the surface, at one meter, at every two meters to 15 m, at every three meters to 60 m, and at every five meters to 95 m or the bottom. Laboratory calibration of the Martek was done prior to field sampling following the manufacturer's instructions. Water samples were also taken with a VanDorn sampler at the surface, 11 m, and 21 m. A modified Winkler titration (APHA 1975) was used to determine the dissolved oxygen (D.O.) content of these samples. These D.O. values verified proper calibration of the Martek meter. Incident light was recorded above the water's surface and at one meter intervals to a depth of 30 m or until light intensity was one percent or less of the incident light (defined as the lower boundary of the euphotic zone [Talling 1962]). Secchi disk readings were taken following the considerations presented by Wetzel (1975).

Isopleths of temperature, pH, dissolved oxygen, and conductivity were plotted for each sample station through time using the USGS program STAMPEDE.

### **Results and Discussion**

Oxygen and pH were not found to be limiting at any time in Libby Reservoir, generally meeting all salmonid requirements as reported in Piper et al. (1982). Dissolved oxygen ranged between 7 and 15 ppm in 1987 (Appendix B, Figures B1 through B3), and pH ranged from 6.8 to 8.9 (Appendix B, Figures B4 through B6). Generally those species that live in cold or cool waters of low primary productivity do best at pH 6.5 to 9 (Piper et al. 1982).

Water temperatures ranged from 1°C to 21°C in 1986, and from 1°C to 25°C in 1987. Maximum surface temperatures occurred in

Table 4. Limnological sampling frequency on Libby Reservoir from 1983 through 1987.

Year	Months												Year total
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
1983	-	-	-	-	-	-	-	112	2	1	1		8
1984	11	12	2	2	3	2	2	2	2	11			20
1985	1	-	-	1	2	2	2	2	2	2	1	1	16
1986	1	-	-	1	2	2	2	2	2	2	1	1	16
1987	1	-	1	1	1	1	1	-	1	-	1	-	8
Totals	4	1	2	5	7	7	10	7	9	8	5	4	68

late July and August of both years. Optimum temperature range for growth of kokanee salmon, currently the most sought-after fish in the reservoir, is listed as 10-15°C by Piper et al. (1982). Optimum growth conditions in terms of temperature occur from May through November for the Tenmile and Rexford areas and May through October for the Canada area (Appendix B, Figures B7 through B9). The greatest volume of water with these temperatures is generally present from May through July.

Libby Reservoir did not thermally stratify to any degree during 1986 or 1987, as evidenced by the wide spacing of isotherms on the Tenmile, Rexford, and Canada graphs (Appendix B, Figures B7 through B9). The weak thermal structure of Libby Reservoir was largely attributed to reservoir operation. Water movements in reservoirs result from the interactions of reservoir operations, basin morphology and climate, thermal stratification, and currents (Woods and Falter 1982). In many reservoirs, the unsteady nature of inflow and outflow currents (i.e. reservoir operation) is largely responsible for continual water movement, and is strongly related to water quality parameters such as temperature and oxygen (Wunderlich 1971).

Euphotic zone depth averaged 10 m in 1986 and 8 m in 1987 (Table 5). lowest levels of light penetration occurred during spring runoff; euphotic zone depth averaged 5 m in June of 1986 and 4 m in May of 1987. These low levels are due to turbidity caused by large loads of suspended sediments carried into the reservoir by the Kootenai River during spring runoff (Bonde and Bush 1975); the effect is compounds by the low water volumes in the spring resulting from the winter draft of the reservoir. Deepest euphotic zone depths occur during the winter months in the Tenmile area and during late winter and summer months in the Rexford and Canada areas, respectively (Appendix B, Figures B10 through B12).

Table 5. Mean euphotic zone depth (m) (top line) and secchi disk depth (m) (bottom line) measured in Libby Reservoir, July 1983 through December 1987. Sample size is in parenthesis.

Month	1983	1984	1985	1986	1987	Monthly means
Jan	-- (0) --	12 (3) --	12 (1) 3.3	12 (2) 3.8	12 (1) 3.1	12 3.5
Feb	-- (0) --	10 (1) --	4 (1) 2.8	-- (0) --	-- (0) --	7 2.8
Mar	-- (0) --	12 (2) --	-- (0) --	-- (0) --	10 (2) 3	9 3
Apr	-- (0) --	14 (4)	7 (3) 2.2	8 (2) 0.9	8 (2) 2.6	8 1.9
May	-- (0) --	10 (4) --	8 (4) 2.3	8 (5) 2.3	4 (3) 1.4	7 2.0
Jun	-- (0) --	6 (4)	6 (6) 1.8	5 (5) 2.0	8 (3) 3.5	5 2.2
Jul	13 (2) 4.3	-- 7 (7)	10 (6) 3.8	9 (6) 3.6	10 (3) 4.2	9 3.7
Aug	11 (5) 3.9	10 (8)	12 (7) 6.0	12 (6) 5.8	-- --	11 4.0
Sep	13 (9) 6.2	-- 13 (5)	12 (6) 5.6	13 (5) 5.6	7 (3) 5.8	12 5.7
Oct	15 (7) 6.2	14 (6) --	12 (6) 5.6	11 (7) 5.6	-- 5.8	13 5.7
Nov	12 (2) --	10 (3) --	11 (3) 2.5	10 (2) 2.8	4 (2) 3.0	10 2.8
Dec	12 (2) --	14 (2) --	13 (1) 3.2	8 (3) 3.3	-- --	11 3.2
Annual Average	13 4.9	11 --	10 3.8	10 4.0	8 3.5	10 3.6

## PRIMARY PRODUCTION

### Methods

Primary production measurements were made at three-week intervals from May to November, 1986, and then at four-week intervals until April, 1987. Four stations within the reservoir were monitored: Tenmile, Stonehill near Peck Gulch, International Border, and Canada near Kikomun Provincial Park. Primary productivity was measured using the light/dark bottle technique and  $^{14}\text{C}$  radioisotope tracer (Wetzel and Likens 1979). This method is particularly applicable to slow moving or standing, low productivity waters such as Libby Reservoir (Janzer et al. 1973). For each station, water samples were collected at discrete depths (surface, 1, 3, 5, 10, 15, 20, and 25 m) and subsamples drawn off into one clear and one opaque bottle. These were inoculated with  $^{14}\text{C}$  and then suspended at the collection depth and incubated for three to seven hours near midday. The algae from each bottle was then separated by filtration for analysis of  $^{14}\text{C}$  uptake through liquid scintillation counting. Total daily solar radiation was measured by a pyronometer set and monitored at the Murray Springs Fish Hatchery.

Rates were estimated using the following general equation and

$$\text{solving for } ^{12}\text{C uptake':} \quad \frac{^{12}\text{C uptake}}{^{12}\text{C available}} = \frac{^{14}\text{C uptake}}{^{14}\text{C available}}$$

where ' $^{12}\text{C available}$ ' was estimated from alkalinity measurements, ' $^{14}\text{C available}$ ' was calculated from the specific activity of the  $\text{NaH}^{14}\text{CO}_3$  stock solution and ' $^{14}\text{C uptake}$ ' was measured by liquid scintillation counting of the filtered algae.

Daily volumetric production rates ( $\text{mgC}/\text{m}^3/\text{d}$ ) at each station were calculated from the rates measured during the incubation period by normalization to total daily light (total langley's/langley's during the incubation period). Volumetric rates for each depth sampled were then integrated to give a water-column or areal productivity rate ( $\text{mgC}/\text{m}^2/\text{d}$ ).

### Results and Discussion

Highest daily areal productivity rates were measured at the Tenmile and Border stations but rates were highly variable between sampling areas (Table 6). Direct statistical comparisons of differences among stations were not performed because photosynthetic activity is not constant throughout the light day or euphotic zone, nor is it symmetrical with regard to midday (Vollenweider 1965). Therefore, differences in the period of the light day sampled preclude statistical tests between areas.

Table 6. Primary productivity data collected from Libby Reservoir, May 1986 through January 1987. The rates are expressed as daily areal rates ( $\text{mgC}/\text{m}^2/\text{d}$ ).

Date	Primary productivity ( $\text{mgC}/\text{m}^2/\text{d}$ )			
	Tenmile	Pinkham	Border	Canada
May 15	278.8	133.7	133.1	--
June 5	337.4	311.7	123.9	--
June 26	--	--	--	206.6
June 27	401.5	272.2	365.3	--
July 17	--	--	242.7	288.5
July 18	588.0	391.5	--	--
Aug 7	--	--	488.6	--
Aug 8	505.0	391.1	--	--
Aug 11	--	--	--	314.4
Aug 28	--	--	419.1	329.1
Aug 29	369.3	382.0	--	--
Sept 18	--	--	264.2	225.2
Sept 19	449.6	308.2	--	--
Oct 9	--	--	168.2	180.8
Oct 10	308.5	316.1	--	--
Dec 11	88.1	63.9	85.6	--
Jan 15	189.1	--	--	--

Daily areal productivity rates were highest during July, with measured productivity in 1986 ranging between 63.9 and 588.0 mg C/m<sup>2</sup>/d (Table 7). This is similar to the production rates measured from 1972 to 1980 reported by Woods (1982) as ranging from 0.4 to 420 mg C/m<sup>2</sup>/d.

Monthly averages of observed secchi disk depth, surface water temperature and month of the year explained 94 percent of the variation in 1986 phytoplankton productivity rates ( $R^2=0.941$ ;  $F_{3,3}=15.94$ ;  $P=0.0239$ ). Similarly, monthly averages of the euphotic zone depth, surface water temperature and month of the year also explained 94 percent of the variance in measured productivity rates ( $R^2=0.939$ ;  $F_{3,3}=15.56$ ;  $P=0.0247$ ). Within any given area, the lowest daily areal primary production rates were observed in December (Table 7). These results imply that the overriding factors determining productivity in Libby Reservoir at this time are light and temperature. Woods (1982) presented the results of multiple regression analysis in which six variables were used to predict daily areal primary productivity in Libby Reservoir from data gathered during 1972 to 1975. The relationship developed explained 50 percent of the variance. Disparity with our results may reflect the different techniques used, especially with regard to integration of incident light during incubation of samples, or may indicate a real change in the importance of factors limiting photosynthetic activity on Libby Reservoir.

Woods (1979) concluded that the quantity of light received by phytoplankton was the dominant influence on primary productivity in the reservoir: however no one single environmental variable fully accounted for the seasonal variations in primary productivity. He identified three processes as having an effect on the light available to phytoplankton. First, a weak thermal structure in the reservoir allowed phytoplankton to be circulated out of the euphotic zone. The operational schedule of the reservoir, in conjunction with large seasonal inflows, produced the weak thermal structure. Second, the large turbid inflows during spring runoff substantially reduced euphotic zone depths. Third, the amount of light available was largely dependent on seasonal and meteorological variations in incident solar radiation.

The extent to which nutrients determine phytoplankton production in Libby Reservoir is not fully known. Woods and Falter (1982) reported that nitrogen and phosphorous data taken concurrently with areal productivity did not appear to account for the seasonal variations in productivity. During 1972 to 1980, the reservoir was classifiable as eutrophic, based on Vollenweider's (1975) nutrient loading model (Woods 1982). However, the average daily areal primary productivity during 1972 to 1980 characterized its trophic state as oligotrophic. This discrepancy is attributed to the failure of the nutrient loading model to adequately account for limnological processes within the reservoir which affected the availability of influent nutrient loadings to phytoplankton (Woods 1982).

Table 7. Mean monthly values of variables used in regression analysis of daily areal primary productivity measured in Libby Reservoir, 1986.

Month	Productivity rate (mgC/m <sup>2</sup> /d)	Surface temp (°C)	Euphotic zone (m)	Secchi depth (m)
May	181.67	8.1	8	2.3
June	288.37	17.7	5	2.0
July	377.67	19.5	9	3.6
Aug	399.81	20.9	12	5.8
Sept	249.43	15.8	13	5.6
Oct	243.41	11.9	11	5.0
NOV			10	2.8
Dec	79.20	4.7	8	3.3

Our technique assumes that all primary productivity is from phytoplankton and that periphyton primary productivity was minimal, which can generally be assumed in large, deep lakes (Likens 1975). Calculations assume that photosynthetic activity is constant through the day, which it is not, but does vary least between the second and fourth light periods (Vollenweider 1965), when our sampling was conducted. Also, the method used to measure productivity quantified particulate organic carbon, not dissolved organic carbon, which may be important at low phytoplankton growth rates (Harris 1986). Another potential bias inherent with the  $^{14}\text{C}$  light and dark bottle method is that the in situ incubations create an artificial environment by isolating phytoplankton from turbulence and circulation through light gradients. Woods and Falter (1982) believed this bias was existent on Libby Reservoir, but minimal.

## SECONDARY PRODUCTION

### DATA ANALYSIS

Data sets were analyzed using Statistical Package for Social Sciences (SPSS, Nie et al. 1979) and Statgraphics (Statistical Graphics corporation 1987) plotting routines. Parametric analysis techniques were used whenever possible because these methods are useful in summarizing the underlying structure of a body of data (Andrews et al. 1971). Transformations to normalize data were derived following the techniques presented by Taylor (1965). Statistical significance for all tests was chosen as  $p < 0.05$ .

### BENTHOS

#### Methods

Three replicate dredge samples were collected from three elevational strata in each area. The three elevational strata were classified as: frequently dewatered or shallow (between full pool and the 2,369-foot contour), occasionally dewatered or mid (between 2,368- and 2,287-foot contours), and permanently wetted or deep (below the 2,287 foot contour). Samples were not collected in substrates exposed by drawdown.

Sampling was performed using a Peterson benthic dredge equipped with two auxillary weights and ventilation holes in the top to minimize shock waves. The dredge has an empty weight of 93 pounds and a sampling area of one square foot. A hydraulic winch spooled with 1/4-inch aircraft cable lowered the dredge to sample depths determined by sonar. Samples were transferred to sealable buckets and brought back to the lab for analysis.

Benthic samples were wet-sieved using 5.6-, 0.85- and 0.52-mm sieves. The material retained in the 0.52-mm sieve were brought to the laboratory where all macroinvertebrates were picked from the sample and identified to order or class (Diptera and Oligocheatea). Samples were preserved in a formalin preservative prior to fall 1986 and in a 95 percent ethanol solution after fall 1986. The number of each order or class was recorded. Densities were expressed as number per square meter of reservoir bed by elevational strata and geographic area.

As stated above, all ANOVA tests were performed by averaging the three replicates for each sample aone and date and using a log transformation to normalize the data.

#### Results and Discussion

A total of 635 benthic samples were collected between 1983 and 1987. forty-four percent of the samples were taken in the Temmile area, 42 percent in the Rexford area, and 14 percent were collected in the Canada area. Sampling effort was evenly distributed among the drawdown zones; the shallow zone comprised

32.4 percent of the samples, the mid zone comprised 34.2 percent, and the deep zone made up the remaining 33.4 percent.

Existing reservoir surface elevations on sampling dates ranged between 2,350 ft msl and full pool (2,459 ftmsl). Samples were collected from depths of 0.9 (3 ft) to 82 m (270 ft).

From 1983 to 1987, benthic invertebrate densities in the shallow, mid and deep zones of Libby Reservoir averaged 178.7, 569.9, and 1,099.8 organisms/m<sup>2</sup>, respectively (Table 8). The densities of dipterans in Libby Reservoir were slightly higher than in nearby Hungry Horse Reservoir (May 1988), which averaged 337 dipterans/m<sup>2</sup>. When compared to North American reservoirs in general, densities of dipterans in Libby Reservoir are low. For example, Cowell and Hudson (1968) recorded 60,620 chironomids/m<sup>2</sup> in Lake Francis Case Reservoir in the Missouri River system.

Studies by Grimas (1961) on a Swedish lake, and Peterka (1972) on a non-fluctuating reservoir in North Dakota, show that benthos densities generally decline from the littoral to the profundal zone. The reverse pattern of abundance existed in Libby Reservoir during spring and fall (1984-1987), as density of dipterans declined from the profundal to the littoral zone (Figure 4). Our results are consistent with the findings of Kaster and Jacobi (1978) in Big Eau Pleine Reservoir which also experiences water level fluctuations.

The exact nature of drawdown effects on benthos in Libby Reservoir is unclear. Grimas (1961) and Fillion (1967) found the greatest abundance of benthos immediately below the drawdown limit. Between 1983 and 1987, the drawdown limit in Libby Reservoir varied by 8.5 m. In one year, 1983, the mid zone was not even partially dewatered. The deep zone of Libby Reservoir, in which there was no dewatering during the study period, probably serves as a refuge for dipteran larvae during the period of drawdown. Unexplained is why our data do not support a similar role for the mid zone. In all years studied, the deep zone had higher densities of dipterans in spring (March, April, May, June) than the other two zones (Figure 5). During summer (July, August, September) the mid zone had greater densities than the deep zone (Figure 6). The reduced density in the deep zone from spring to summer is probably the result of losses during the peak spring emergence from the deep zone and dispersal of larvae from the deep zone to the expanding mid and shallow zones as the reservoir fills. Many dipteran larvae, especially early instars, demonstrate positive phototropism which allows efficient colonization of advancing water margins (McLacklan 1969, Oliver 1971).

The shallow and mid zones showed continuous increases from spring through fall suggesting that those zones were being colonized from the deep zone at a rate exceeding losses from emergence. Since the seasonal abundance patterns in the shallow and mid zones were so similar, they both seem to be strongly influenced by colonization. Therefore, dipterans in Libby

Table 8. Benthic invertebrate mean densities for Libby Reservoir, 1983 through 1987.

Year	Area	Frequency Wetted	Diptera N/m <sup>2</sup>	Variance	Oligochaeta N/m <sup>2</sup>	Variance
1983	TENMILE	shallow	39.4	270.4	3.6	38.9
		mid	157.7	4,320.1	7.2	154.1
		deep (N)	311.8 9	29,954.3	50.2 9	1,193.4
	REXFORD	shallow	125.5	9,292.1	3.6	38.9
		mid	666.7	231.1	182.8	5,788.9
		deep (N)	2,132.6 8	1,626,936.4	276.0 8	11,248.1
	CANADA	shallow (N)	60.9 3	500.4	75.3 3	10,513.0
1984	TENMILE	shallow	130.8	28,324.5	0.0	0.0
		mid	473.1	178,296.1	159.5	45,443.4
		deep (N)	497.0 27	69,385.6	86.0 27	5,404.4
	REXFORD	shallow	107.5	18,869.6	0.0	0.0
		mid	534.0	166,581.2	250.9	99,298.7
		deep (N)	1,285.5 27	1,312,474.4	457.6 27	233,727.8
	CANADA	shallow	630.8	492,618.3	60.9	11,138.6
		deep (N)	659.5 6	52,782.7	953.4 6	668,836.2
1985	TENMILE	shallow	138.7	29,586.1	14.2	1,965.3
		mid	574.6	252,217.7	121.5	13,477.2
		deep (N)	463.7 73	107,895.5	239.7 73	80,245.0
	REXFORD	shallow	51.1	3,599.0	3.4	57.3
		mid	356.0	291,055.2	253.2	81,110.4
		deep (N)	438.3 66	169,386.7	748.6 66	297,353.9
	CANADA	shallow	106.6	35,071.0	149.7	64,758.9
		deep (N)	61.0 18	5,069.6	227.6 18	46,272.0
1986	TENMILE	shallow	180.2	22,062.0	1.0	31.6
		mid	662.4	324,285.8	201.1	25,503.9
		deep	667.3	341,998.1	284.9	71,194.3
		(N)	108		108	

Table 8 (continued).

Year	Area	Frequency Wetted	Diptera		Oligochaeta	
			N/m <sup>2</sup>	Variance	N/m <sup>2</sup>	Variance
1987	REXFORD	shallow	251.6	110,858.9	1.0	17.1
		mid	259.6	94,894.2	91.6	14,405.2
		deep	687.5	168,577.2	1,393.3	1,321,982.4
		(N)	101		101	
	CANADA	shallow	138.1	32,232.7	123.2	72,920.8
		deep	133.6	15,558.6	388.2	524,792.3
		(N)	45		45	
	TENMILE	shallow	17.9	721.3	.9	9.7
		mid	223.9	22,372.9	83.7	9,743.5
		deep	422.8	80,725.5	425.6	150,290.7
		(N)	54		54	
	REXFORD	shallow	19.7	437.6	0.0	0.0
		mid	241.7	105,903.6	64.1	26,574.4
		deep	671.1	350,797.3	609.1	207,718.6
		(N)	54		54	
	CANADA	shallow	48.4	682.6	19.7	1,037.3
		deep	59.2	4,058.5	43.0	5,086.5
		(N)	12		12	

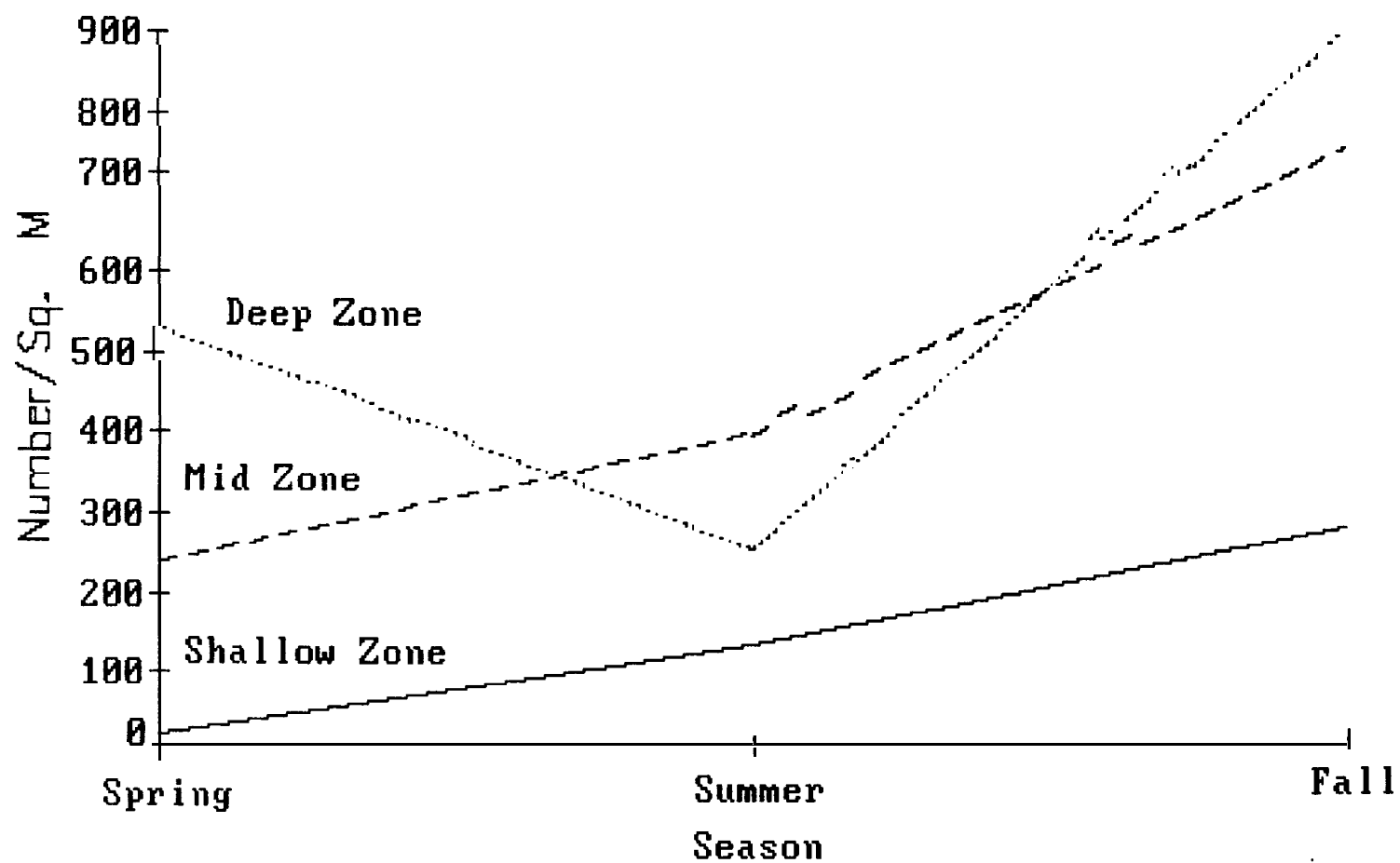


Figure 4. Average number of dipterans per square meter in spring (March through June), summer (July through September), and fall (October through December) in three depth zones in the Tenmile and Rexford areas of Libby Reservoir, 1984 through 1987.

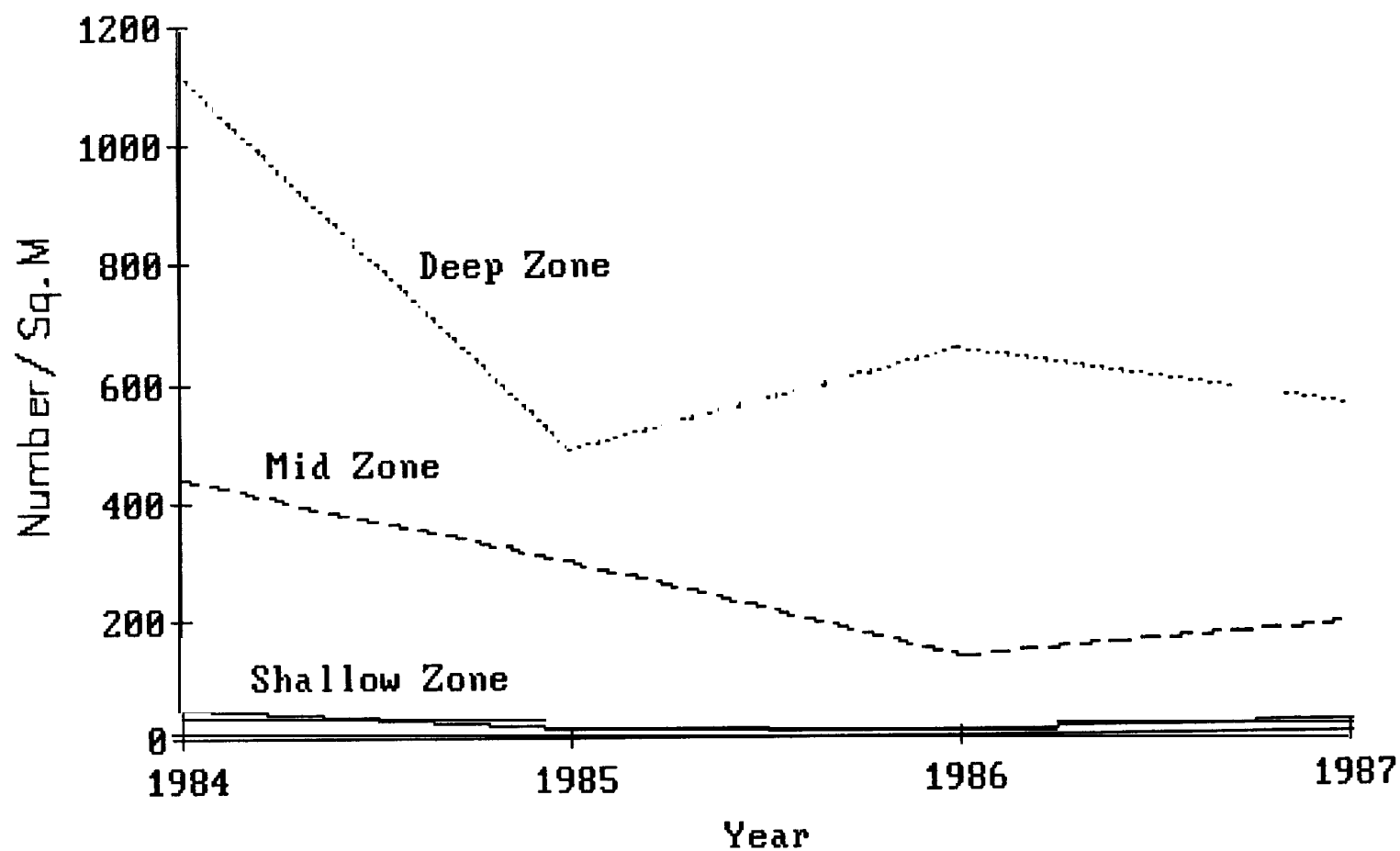


Figure 5. Average number of dipterans per square meter during spring (March through June) in three depth zones in the Tenmile and Rexford areas of Libby Reservoir, 1984 through 1987.

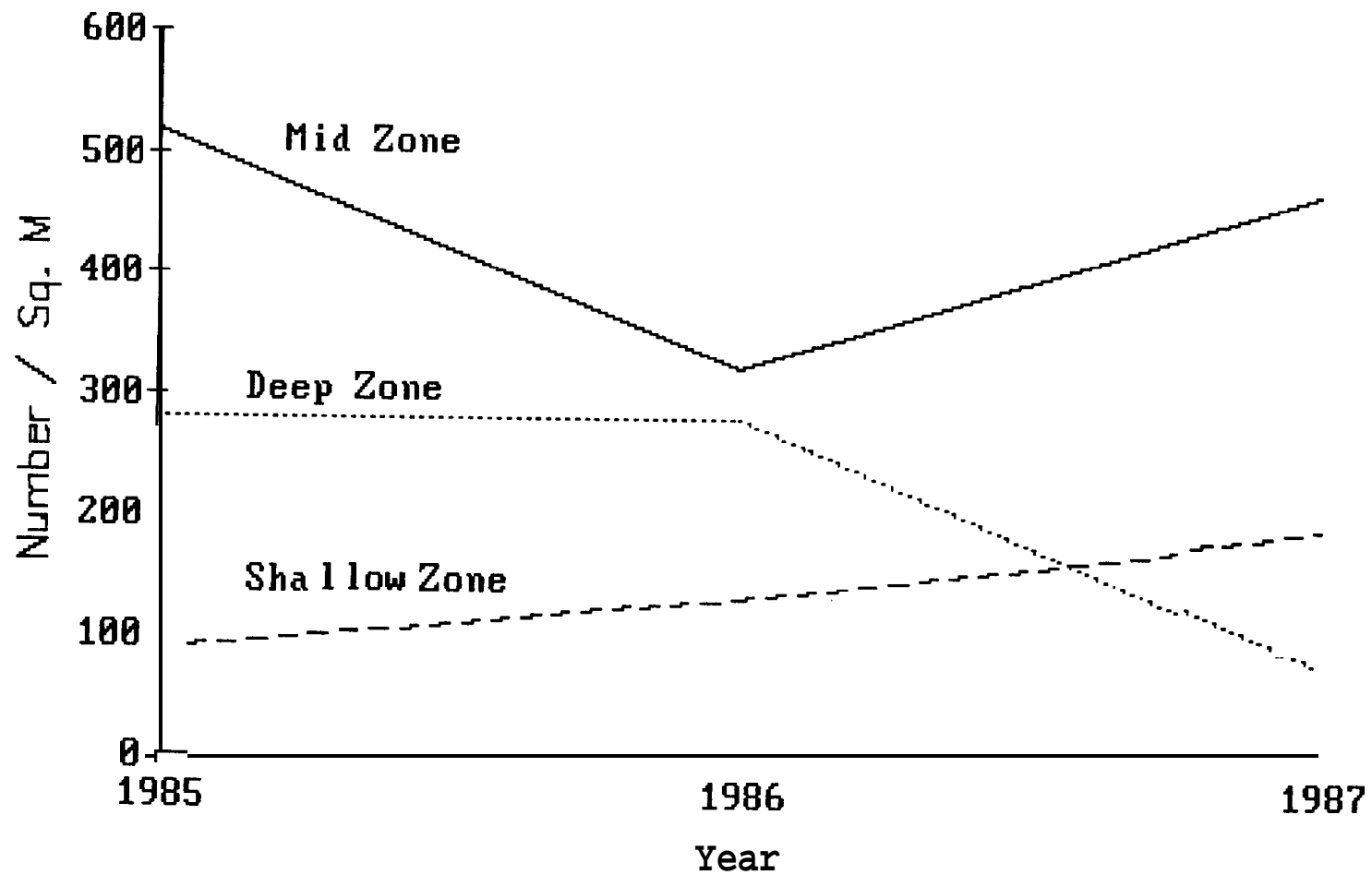


Figure 6. Average number of dipterans per square meter during summer (July through September), in three depth zones in the Tenmile and Rexford areas of Libby Reservoir, 1985 through 1987.

Reservoir do not seem to concentrate near the drawdown limit as dipterans in the reservoirs studied by Grimas (1961) and Fillion (1967). Identification of chironomid larvae to genus and species groups as planned for 1989 may further elucidate the effects of drawdown by zone.

Diptera constituted the predominant group in the benthic fauna of each drawdown zone in Libby Reservoir. The shallow zone contained the highest percentage of Diptera, comprising an average of 84.17 percent of the total density for that zone, followed by the mid drawdown zone which averaged 73.99 percent, and the deep zone which averaged 53.81 percent. Total number of Diptera encountered in the samples ranged from zero to 278 organisms with an overall mean of 34.2 per sample. Total number of Oligochaeta in our samples ranged from zero to 941 organisms, but the overall mean was 23.1 per sample. An overall average of 69.9 percent of all benthic invertebrates sampled were Diptera.

Overall benthic densities varied among the study areas of the reservoir, and were related to the drawdown zone and the class of organism. In the frequently dewatered or shallow zone, density of Oligochaeta for 1983 through 1987 was statistically different ( $F_{2,30}=16.51$ ,  $p<0.0001$ ). Multiple comparisons (SNK) indicated that Canada had a statistically higher mean density of Oligochaeta than the other areas of the reservoir. These conditions did not exist between the Rexford and Tenmile areas.

Maintenance of the higher densities of Oligochaeta in dewatered drawdown zones can occur by the organism remaining in the substrate or by rapid recolonization of Oligochaeta in early summer when the zone is inundated. Recolonization is dependent on the nature of the substrate (Kaster and Jacobi 1978), and possible substrate differences (particle size, slope, proximity to water) between Canada (which remains the most riverine) and the other two areas may account for the varying abundance of Oligochaeta. In Big Eau Pleine Reservoir, Wisconsin, benthos recolonized more rapidly and were of greater density in substrates containing large amounts of detritus or organic matter than in sandy substrates (Kaster and Jacobi 1978).

Greater nutrient levels in the Canada area relative to the Tenmile and Rexford areas may also explain the increased abundance of Oligochaetes in Canada. Dominance of oligochaetes in the macrobenthos is typical of eutrophic waters (Beeton 1961, Thut 1969). Oligochaetes generally increase in dominance in the benthos during the processes of eutrophication (Wetzel 1975).

In the occasionally dewatered or mid zone of the reservoir, benthic densities varied between the Tenmile and Rexford areas. (The Canada area was not deep enough to have a mid zone-- 91- to 172-foot drawdown.) Overall benthic invertebrate density was significantly greater in the Tenmile area ( $F_{1,67}=5.327$ ,  $p=0.024$ ). Greater numbers of Diptera accounted for the statistical significance ( $F_{1,66}=7.905$ ,  $p=0.0065$ ); mean density of Diptera

(replicates averaged) in the Tenmile area was  $386.6/\text{m}^2$  versus  $188.1/\text{m}^2$  in the Rexford area.

The permanently wetted or deep zone in the Rexford area contained a higher density of Diptera and Oligochaeta than the other two areas. Mean density (replicates averaged) of Diptera in the Rexford area for 1983 through 1987 was 482.3 per square meter. This value is significantly greater than those found in the Canada area, but not in Tenmile.

In the permanently wetted zone, Student-Neuman-Keuls multiple range test indicated that Oligochaeta densities were significantly greater in the Rexford area than in the Tenmile and Canada areas. ( $F_{2,74}=14.434$ ,  $p<0.0001$ ).

## **SURFACE MACROINVERTEBRATES**

### **Methods**

Macroinvertebrates on the surface of the reservoir were sampled using a tapered net constructed of 3.17-mm mesh near the mouth and 1.59-mm mesh in the midsection that tapered to a 100-mm diameter collar. The mouth of the net was rectangular 1.0 m wide by 0.3 m high. A removable plastic bucket with a panel of 80-micron nitex netting was attached to the collar at the end of the net. The net was towed so that it sampled a 1-m swath of the reservoir's surface.

Three sites were sampled biweekly or monthly. Sample sites were selected randomly using established transects as starting points. Each sample site consisted of two sampling runs, one nearshore (less than 100 m from shore) and one limnetic (greater than 100 m from shore). Nearshore tows were made in a zig-zag pattern along shore while limnetic tows were made in a direction angling away from shore.

Initially, surface tows were made by towing the net for ten minutes at a constant speed of 1.0 m/sec. After July, 1985, this method was simplified by the use of a digital knotlog (Signet, Model MK 267). This instrument accurately measured the sampling distance of 600 m.

All macroinvertebrates were removed from the bucket and net after each tow and placed in a labeled vial containing a formalin preservative (prior to fall 1986) or in a 95 percent ethanol solution (after fall 1986). Macroinvertebrates in each sample were identified to order and counted in the laboratory. Blotted wet weights were measured in grams. Densities and biomasses of surface macroinvertebrates were expressed as number per hectare and grams per hectare, respectively.

## Results and Discussion

Surface insect tows were performed between 1983 and 1987. There appeared to be very little consistency in insect densities among years or distance from shore, and variances were very high (Table 9). A maximum density of over 1,950 terrestrial invertebrates per hectare was attained in the nearshore zone of the Tenmile area in 1985, a more than 140-fold increase over the minimum value recorded in the nearshore zone of the Rexford area in 1983.

The yearly trend of surface invertebrate densities was upward through 1985. A sharp decrease was experienced in 1986 and then densities increased again in 1987. This was true for the Tenmile and Rexford areas; conversely, the densities in Canada were relatively high in 1983 and tended to decrease except in 1986 when numbers increased. Water levels were similar in 1986 to other years so there is no obvious explanation for the difference.

Aquatic insect densities were generally lower than those of terrestrial invertebrates but followed the same trends. Densities ranged from a low of 6.4/ha in 1983 in the nearshore zone of the Rexford area to a high of greater than 200/ha in the nearshore zone of the Canada area in 1987. The lower number of dipterans caught does not parallel the numbers that were seen on emergence traps. This difference may be due to difficulty of capture. The small size of some dipterans (Meritt and Cummins 1984; Oliver 1971) and their habit of generally emerging in darkness and flying immediately upon emergence (Murdie 1959) may allow the dipterans to escape through the mesh or avoid capture.

Yearly trends in density for aquatic invertebrates were similar to those of the terrestrials. The densities of aquatic invertebrates in the Tenmile and Rexford areas mirrored the terrestrials during the study period, showing increases through 1985 followed by a large decrease in 1986 and an increase through 1987. The density of terrestrial and aquatic invertebrates decreased in the Canada area from 1983 to 1984, but increased from 1985 to 1987.

The densities of macroinvertebrates captured in the nearshore zone were not consistent with those in the limnetic zone. Although the highest number of terrestrials were generally captured near shore, variances were so high that the difference was not statistically significant ( $F_{1, 780} = 0.2290$ ,  $p = .6324$ ), and in several instances, higher densities were found in the limnetic zone (Table 9). Wind, water currents, and wave action are the likely reasons for the density differences between the two zones.

A pattern appeared when densities of invertebrates were compared among areas. It was found that terrestrial numbers were generally lower and aquatic numbers were generally higher in the Rexford area than in the Tenmile area. This was true on both a

Table 9. Mean densities of surface invertbrate for Libby Reservoir, 1983 through 1987.

Year	Area	Nearshore or Limnetic	Terrestrial no./ha	Variance	Aquatic no./ha	Variance
1983	Termile	Nearshore	47.9	4294.2	9.3	253.4
		Limnetic	158.5	186330.3	10.9	184.2
		(N)	30		30	
	Rexford	Nearshore	13.9	241.1	6.4	90.1
		Limnetic	40.0	1973.7	10.8	260.7
	(N)	24		24		
Canada	Nearshore	227.0	296361.1	62.6	9969.7	
	Limnetic	29.8	2462.2	15.7	543.5	
	(N)	17		17		
1984	Termile	Nearshore	229.2	256183.9	54.3	10181.9
		Limnetic	114.1	114143.1	52.0	30139.5
		(N)	82		82	
	Rexford	Nearshore	94.5	46097.0	80.0	42940.3
		Limnetic	95.3	91361.9	158.6	241182.3
	(N)	82		82		
	Canada	Nearshore	73.9	9537.0	29.2	1323.8
		Limnetic	73.9	16789.8	18.3	543.7
	(N)	52		52		
1985	Termile	Nearshore	1958.8	74044304.2	145.1	89467.2
		Limnetic	1219.9	28544442.8	64.6	27258.7
		(N)	76		76	
	Rexford	N - o r e	184.5	138104.1	167.8	380333.6
		Limnetic	189.0	151679.2	114.2	107471.7
	(N)	74		74		
	Canada	Nearshore	95.7	28799.6	42.0	3135.8
		Limnetic	69.1	19928.7	38.6	7833.8
	(N)	60		60		
1986	Termile	Nearshore	60.6	16605.8	59.5	20476.0
		Limnetic	51.2	28616.4	32.1	11200.8
		(N)	88		88	
	Rexford	Nearshore	84.0	51913.8	73.4	83792.3
		Limnetic	32.1	2199.6	68.5	64725.8
	(N)	90		90		
	Canada	Nearshore	179.9	480142.5	70.0	23243.7
		Limnetic	386.9	3570524.4	59.4	27163.9
	(N)	54		54		
1987	Termile	Nearshore	765.5	4567614.7	141.1	42079.1
		Limnetic	429.4	579915.1	138.5	73500.5
		(N)	36		36	
	Rexford	Nearshore	122.7	34457.5	140.3	107314.1
		Limnetic	68.8	8458.8	85.6	16789.8
	(N)	36		36		
	Canada	Nearshore	321.0	636969.2	201.1	118552.4
		Limnetic	49.4	5686.3	51.1	6905.9
	(N)	18		18		

yearly and monthly basis (Table 9 and Appendix C, Tables C1 - C18).

A possible reason for the Tenmile area containing higher numbers of terrestrial invertebrates involves the morphology of the reservoir. The banks of the Tenmile area are generally narrow and steep. In contrast, much of the Rexford area is wider and shallower than the Tenmile area, and contains large areas of bays and shallow water. Therefore, when reservoir levels are lowered, large expanses of barren ground are exposed, increasing the distance from water to shoreline vegetation. Norlin (1967) suggested that barren ground facilitates rising thermal air currents that impede transport of airborne insects over a body of water. The effect in the Tenmile area would not be as pronounced since there is less barren ground and the vegetation is closer to the water.

The reason for greater aquatic invertebrate densities in the Rexford area is likely two-fold. First, the substrate composition in the Rexford area may be more conducive to dipteran production, which is consistent with results of the benthic sampling. Densities of dipteran larvae are greater in the permanently wetted zone of the Rexford area than in any Tenmile zone. Secondly, at full pool and during drawdown there remains large areas of relatively shallow water in the Rexford area. This leads to a greater amount of bottom that is euphotic, and hence more productive. Welch et al. (1988) found that dipteran emergence increased with increased primary production. Reservoir morphology in the Tenmile area lacks the positive components for dipteran production that are present in the Rexford area.

All areas were similar with respect to types of invertebrates caught and monthly patterns of capture. The density of individual invertebrate types, in decreasing order, were Hymenoptera, aquatic Diptera, Homoptera, Coleoptera, Hemiptera, and Arachnida.

When viewed monthly, major peaks in densities did not coincide for terrestrials and aquatics. In general, terrestrials remained at relatively low densities through July and then peaked abruptly in August. After August, numbers decreased again but remained at higher levels than months previous to July (Figure 7). Aquatic invertebrate densities peaked in April and May and then to a lesser extent again in August (Figure 8).

Individual invertebrate types varied among months. Aquatic dipterans peaked earliest. They comprised approximately 55 and 65 percent of the total invertebrate drift in April and May, respectively. Surface deposition of Coleoptera was greatest in early summer, peaking in June and comprising about 31 percent of the total input. Input of Hymenoptera (primarily ants) was greatest in August when they comprised almost 45 percent of the total input of surface film invertebrates. Hemiptera and to a lesser extent Arachnida were important from September through November. Homoptera (mostly leafhoppers) were consistently

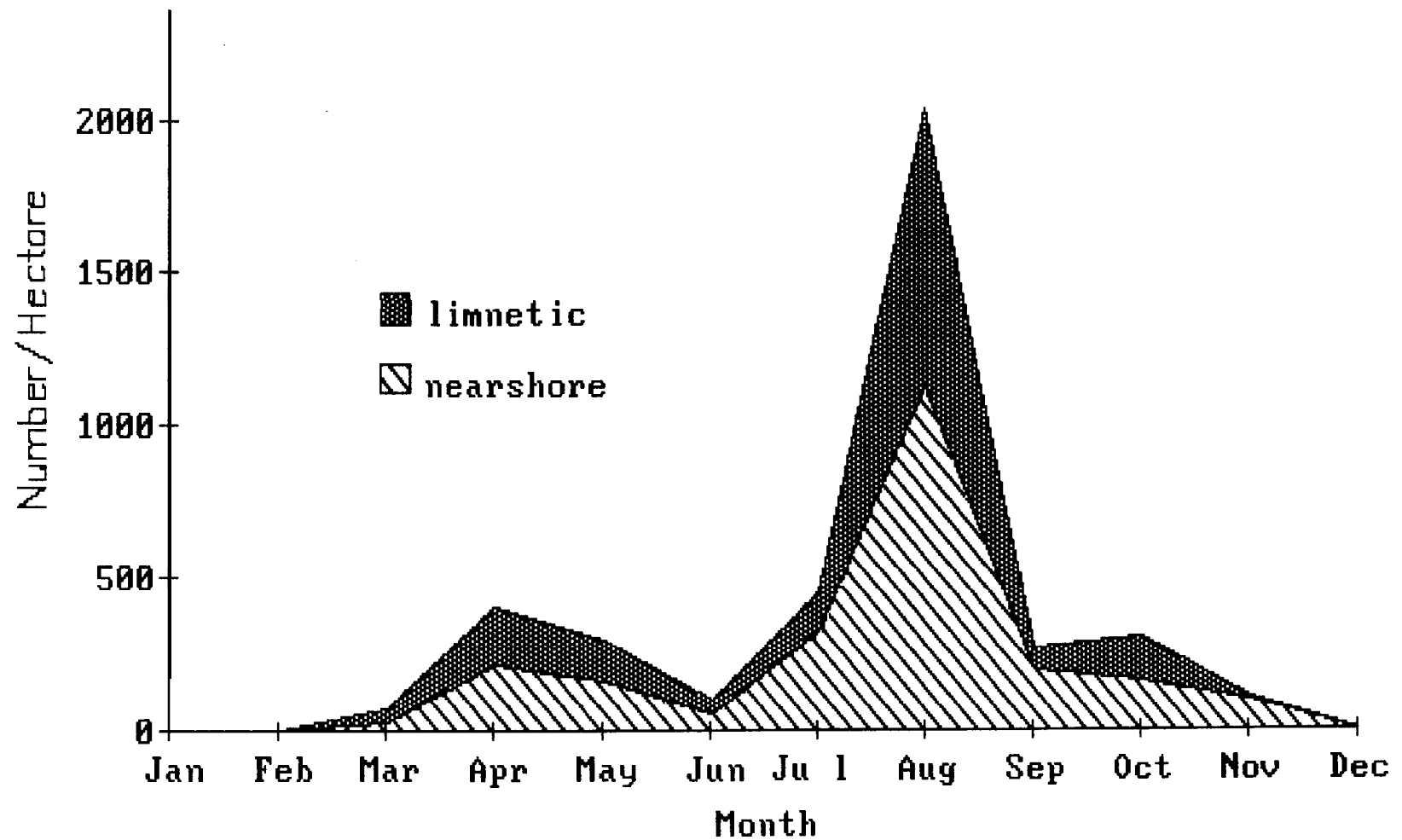


Figure 7.. Estimated densities of terrestrial macroinvertebrates found on the surface of Libby Reservoir, 1983 through 1987.

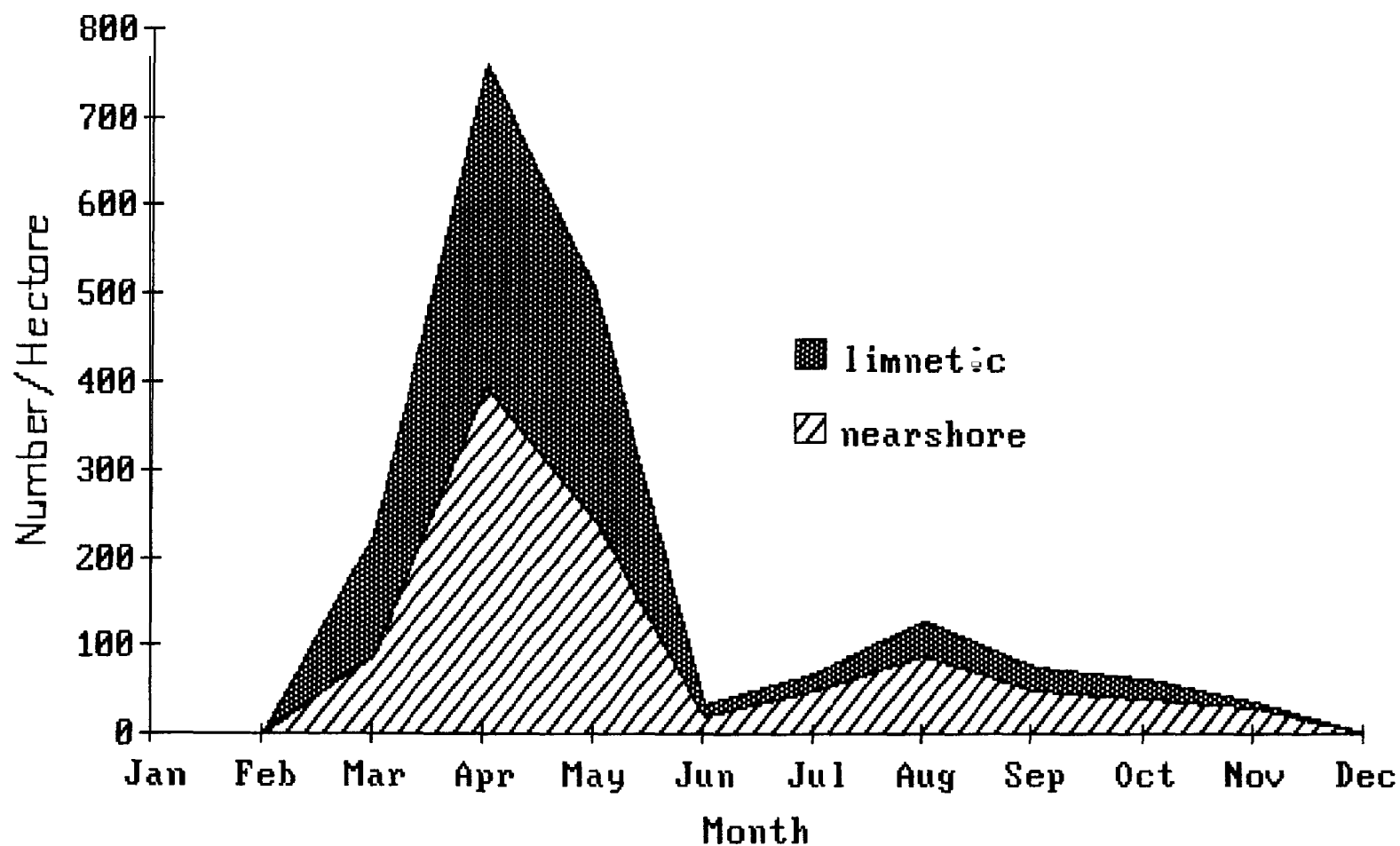


Figure 8. Estimated densities of aquatic macroinvertebrates found on the surface of Libby Reservoir, 1983 through 1987.

important from July through November, comprising about 30 percent of the total input of invertebrates for those months.

Biomass of surface invertebrates followed the same trends as those shown for density (Table 10 and Appendix C, Tables C19 - C36). Tenmile tended to have the greatest terrestrial biomass while Rexford had the greatest aquatic biomass. Terrestrial biomass was greater than 61 percent of total biomass for all months except April and May (56 percent and 43 percent, respectively) and was as high as 98 percent. Two peaks in biomass occurred (Appendix C, Tables C19 - C36). One occurred in April and May and was fueled by the large Coleoptera that were captured. The second peak was seen in August and contained the Hymenoptera that was discussed earlier.

Table 10. Mean biomasses of surface invertebrates for Libby Reservoir, 1983 through 1987.

Year	Area	Nearshore or Limnetic	Terrestrial g/ha	Variance	Aquatic g/ha	Variance
1983	Termile	Nearshore	1.480	26.246	0.033	0.004
		Limnetic	0.662	1.874	0.043	0.016
		(N)	30		30	
	Rexford	N - o r e	0.206	0.210	0.002	0.000
		Limnetic	1.132	7.973	0.034	0.007
		(N)	24		24	
	Canada	Nearshore	0.821	0.925	0.456	0.924
		Limnetic	0.396	0.504	0.326	0.855
		(N)	17		17	
1984	Termile	Nearshore	1.155	5.712	0.284	0.618
		Limnetic	0.596	1.757	0.276	0.860
		(N)	82		82	
	Rexford	Nearshore	0.610	1.274	0.209	0.355
		Limnetic	0.351	0.813	0.598	3.777
		(N)	82		82	
	Canada	Nearshore	0.592	0.898	0.362	0.402
		Limnetic	0.266	0.336	0.093	0.042
		(N)	52		52	
1985	Termile	Nearshore	5.199	188.003	0.316	0.330
		Limnetic	3.548	133.909	0.124	0.098
		(N)	76		76	
	Rexford	Near-shore	1.123	3.804	0.791	5.938
		Limnetic	0.760	1.056	0.341	1.208
		(N)	74		74	
	Canada	Nearshore	0.480	0.556	0.226	0.697
		Limnetic	0.203	0.107	0.062	0.014
		(N)	60		60	
1986	Termile	Nearshore	0.832	2.758	0.122	0.074
		Limnetic	0.666	7.547	0.039	0.017
		(N)	88		88	
	Rexford	Nearshore	2.146	45.579	0.142	0.204
		Limnetic	0.952	0.102	0.159	0.014
		(N)	45			
	Canada	Nearshore	0.420	0.822	0.069	0.066
		Limnetic	0.411	1.639	0.093	0.120
		(N)	54		54	
1987	Termile	Nearshore	3.896	41.472	0.072	0.011
		Limnetic	3.365	71.319	0.054	0.013
		(N)	36		36	
	Rexford	Nearshore	0.728	1.466	0.189	0.236
		Limnetic	0.357	0.283	0.137	0.065
		(N)	36		36	
	Canada	Nearshore	1.364	3.562	0.057	0.009
		Limnetic	0.441	0.845	0.016	0.001
		(N)	18		18	

## AQUATIC INSECT EMERGENCE

### Methods

Insect emergence was determined at the Termile area of Libby Reservoir. Four replicate samples were collected weekly when possible for each of the three determined elevational strata (frequently dewatered or shallow, occasionally dewatered or mid, and permanently wetted or deep).

Sampling was accomplished using a 1-m square emergence trap (Figure 9) constructed of 1/16-inch acrylic (May et al. 1988). Floatation of the trap was accomplished with styrofoam strips that were fastened to the bottom of the trap. Four traps were permanently anchored at each strata and rope was added or removed to prevent them from sinking or floating into an adjacent stratum as water levels raised or dropped.

Vents were cut into the sides of the trap and the catch basin to reduce condensation that might impede movement of an emerging insect. The holes were covered with 120-um cloth to prevent escape of the insects. Automotive antifreeze was used as a preservative for the traps in the field to prevent dessication during the hot months and freezing during the cold months. Each week all traps were checked and their contents removed. Samples were then placed in a formalin preservative (prior to fall 1986) or in a 95 percent ethanol solution (after fall 1986) and transferred to the lab for analysis.

Samples were separated by order (Diptera, other) in the lab and their numbers and dry weights recorded for each of the strata. Densities were expressed as number per square meter and weights as grams per square meter of reservoir by elevational area.

### Results and Discussion

Dipteran emergence was sampled between June and December, 1986, and between April and October, 1987. Emerging insects were almost exclusively dipterans; other types of invertebrates were identified in only two of the 376 samples. Emergence of dipterans differed by year, by drawdown zone, and by season.

In both years, the shallow and mid zones had considerably higher densities and total numbers of emerging insects than did the deep zone (Table 11). In 1986, the highest density was found in the shallow zone ( $18/\text{m}^2/\text{wk}$ ), followed by the mid zone ( $11/\text{m}^2/\text{wk}$ ) and the deep zone ( $3/\text{m}^2/\text{wk}$ ). In 1987, the mid zone had the highest density followed by the shallow zone and the deep zone ( $68$ ,  $52$  and  $34/\text{m}^2/\text{wk}$ , respectively). Statistical comparison of total yearly densities or numbers between 1986 and 1987 was not attempted because of the differences in sampling times.

The monthly trends in emergence were fairly similar between years (Table 12). In 1986, peak emergence was in June in the shallow and mid zones with the mid zone having the greatest

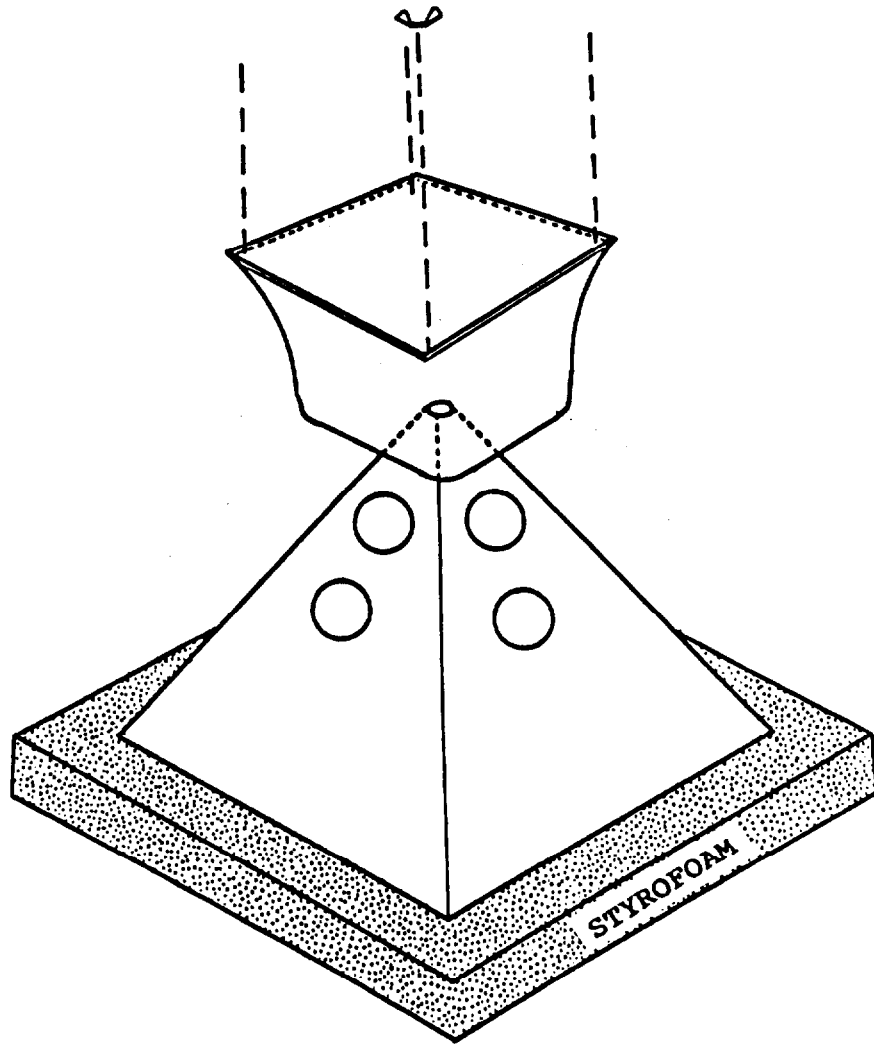


Figure 9. Emergence trap. From May et al. 1988.

Table 11. Mean density (no./m<sup>2</sup>/wk.) and total number of emerging insects by year and zone in the Tenmile area of Libby Reservoir, June through December, 1986, and April through October, 1987.

1986				1987			
Zone	<u>Density</u>	Total	(N)	zone	<u>Density</u>	Total	(N)
	no./m <sup>2</sup> /week				no./m <sup>2</sup> /week		
Shallow	18	1390	77	Shallow	52	4079	79
Mid	11	657	61	Mid	68'	5039	52
Deep	3	54	18	Deep	34	2309	34

Table 12. Monthly mean densities (no./m<sup>2</sup>/wk.) of emerging dipterans in the three elevational strata of the Tenmile area of Libby Reservoir, 1986-1987. Sample size is indicated in parenthesis.

Zone	Month								
	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1986									
Mean surface temp.	—	—	17.5	20.2	20.8	16.4	8.8	0.0	0.0
Res. elev.	—	—	2456	2458	2458	2452	2433	2398	2398
-	-	—	44(2)	7(16)	37(20)	24(16)	4(19)	0(2)	0(2)
Mid	—	—	108(2)	11(16)	8(13)	9(14)	2(13)	0(2)	0(2)
Deep	—	—	—	—	4(4)	4(2)	3(9)	0(2)	0(1)
1987									
Mean surface temp.	1.5	4.7	8.8	14.1	15.5	18.3	12.0	—	—
Res. elev.	2366	2410	2445	2458	2457	2452	2437	—	—
Shallow		112(4)	78(12)	26(15)	61(16)	36(16)	47(16)	—	—
Mid	8(4)	125(23)	143(10)	23(13)	15(7)	34(5)	11(6)	—	—
Deep	21(5)	87(15)	61(12)	3(6)	3(6)	5(10)	7(10)	—	—

density of emergers ( $108/\text{m}^2/\text{wk}$ ). After June, emergence decreased and remained low in the mid zone. In the shallow zone, emergence increased significantly ( $f_{4,72}=26.002, p<.001$ ) in August and September over the July levels; this trend is also supported by surface invertebrate tow data. Densities then decreased to little or nothing for the rest of the year, with no emergers captured in November or December. Sampling in the deep zone did not begin until August, and densities were consistently low ( $0-4/\text{m}^2/\text{wk}$ ). In 1987, shallow zone densities peaked in May ( $112/\text{m}^2/\text{wk}$ ), dropped in June and July, and then increased again in August. Mid zone densities peaked in June ( $143/\text{m}^2/\text{wk}$ ) and decreased through the rest of the year. Rates of emergence in the deep zone was less than in the other two zones, although it had high rates of emergence in May and June ( $87$  and  $61/\text{m}^2/\text{wk}$ , respectively).

Warmer water temperatures in the shallow zone relative to the other zones may account for the high rates of emergence there. Oliver (1971) stated that larvae mature faster in warmer water. In Libby Reservoir, this means there is potential for a continued supply of dipterans throughout the warmer months when water is available. But it is also probable that the full potential of the shallow zone will never be realized due to water level fluctuations which result in a reduction in wetted substrate during the peak emergence times.

The high rates of emergence in May 1987 in the shallow zone were not expected, because of the short interval between the time this zone was wetted and the high rates of emergence. Possible explanations for this include: bi- or multi-voltine species with short life cycles that laid eggs in this zone as soon as it became wetted: eggs or larvae that overwintered in the shallow zone that hatched or matured immediately upon wetting (The phenomenon of over-wintering has been documented by Danell 1981, Merritt and Cummins 1984, Paterson and Fernando 1969); wind, wave or current action forcing emerging pupae into the shoreline or emerging pupae actively seeking warmer water in which to emerge. To more fully understand the true mechanisms affecting the shallow zone emergence patterns, species or genus identification is essential so that life histories and emergence patterns can be ascertained.

The trends of densities with respect to the depth zones do not necessarily follow the trends suggested by benthic sampling. As was stated in the benthos section, the deep zone had the highest number of dipterans and the mid zone was second. The trends are reversed for captures in the emergence traps. There are several possible explanations for this. First, sampling may have been biased by wind and wave action around the traps and currents under the surface, resulting in insects of one zone emerging from the surface in another zone and biasing sample numbers. Second, the large number of benthic dipterans in the deep zone may be serving as a pool for the mid and shallow zone, and are recolonizing the shallower depths (as either eggs or larvae) as water temperatures warm. Third, the shallow zone may support more multi-voltine species, resulting in relatively greater emergence as compared to the deeper zones.

## ZOOPLANKTON

### Methods

Three 30-m (or the entire water column when depth was less than 30 m) vertical plankton tows were made biweekly from April through October and monthly from November through April in each geographic area of the reservoir. A 0.3-m diameter Wisconsin plankton net was used for all tows. One tow was made at the permanent sampling buoy and two tows were made at randomly selected points on established transects in each area.

A plankton trap similar to that described by Schindler (1969) was used monthly to sample the vertical plankton distribution at permanent sample buoys in each geographic area. The trap sampled a 28.1-liter volume of water and each sampling series consisted of nine discrete samples collected at the surface, 3, 6, 9, 12, 15, 20, 25 and 30 m.

All zooplankton samples were preserved in a solution of water, methyl alcohol, formalin and acetic acid from September 1983 through November 1986 and in 95 percent ethyl alcohol from December 1986 to the present. A comparison of zooplankton lengths was performed on 20 subsamples from the December 1986 series, half preserved in formalin and half preserved with alcohol, to document the effect of this preservative change.

Vertical tow samples were diluted in the laboratory to a density of about 20-25 organisms/ml. Zooplankton were enumerated and identified to genus in each of five subsamples (5 ml) taken from the solution. Subsamples were averaged to estimate densities (number per liter) of zooplankton. Schindler trap samples were counted in entirety, and all zooplankton were identified to genus. For both methods, carapace lengths of individual planktors were measured; for vertical tows, all individuals were measured from one randomly chosen subsample; for Schindler samples, up to 20 individuals were measured from each sample. Carapace length data were segregated into 0.5-mm length groups for each genus and each group was averaged. Biomass of zooplankton was estimated using the length-weight relationship described by Shepard (1985).

To determine if statistical differences in zooplankton abundances existed between the reservoir study areas or within the years of the study, the Kruskal-Wallis nonparametric analysis of variance test and nonparametric Tukey-type multiple comparisons were applied (Zar 1984). Comparisons were performed after the Kruskal-Wallis test revealed differences existed at the 0.05 level of significance. Replicates collected on each sample date were averaged within each study area for the statistical analysis.

## Results and Discussion

### Horizontal Distribution

From September 1983 through September 1987, 434 vertical plankton tows were collected from Libby Reservoir. Surface temperatures ranged between 6 and 24.8°C during the sampling period. Sampling occurred when reservoir elevations ranged between 2,342 ft above msl (117-foot drawdown) and full pool (2,459 ft).

Irving (1987) identified eleven species of macro-zooplankton in Libby Reservoir during 1977 and 1978 (Table 13) and it is likely that these are the species currently present in Libby Reservoir. The most abundant species he encountered were Daphnia schodleri, Diaptomus tyrrelli, and Cyclops bicuspidatus thomasi.

There were four main genera of zooplankton identified in Libby Reservoir during this study: Bosmina, Cyclops, Diaptomus, and Daphnia. The reservoir also contained limited numbers of the larger zooplankton, Epishura and Leptodora, which generally comprised less than one percent of the zooplankton community.

The copepods, Diaptomus and Cyclops, comprised the greatest portion of zooplankton sampled in the reservoir: combined they accounted for 67.5 to 77.7 percent of the zooplankton population from 1983 through 1987 (Table 14). Cladoceran densities, particularly Bosmina, varied greatly during the five years of sampling. In 1984 and 1985, Bosmina comprised 9.3 percent and 6.7 percent of the zooplankton population, respectively, while in 1983 and 1986, Bosmina accounted for 1.1 percent and 0.4 percent, respectively.

The apparent changes in the zooplankton community structure, especially the increase in importance of Bosmina in 1984 and 1985, may be related to the kokanee population cycle. When Bosmina were at their highest abundance during the study period, densities of kokanee were at their peak. Because kokanee apparently prefer Daphnia, a change in this competing species may have favored an increase in the smaller, less utilized (by kokanee) Bosmina. Hrbacek (1962), and Brooks and Dodson (1965) clearly demonstrated that predation plays a dominant role in maintaining plankton community structure. Hall et al. (1970) concluded that vertebrate and invertebrate predation had profound effects on the diversity and size distribution of zooplankton, but only affected production at low nutrient levels. Kerfoot (1974) also stated a similar relationship between the abundance of Daphnia and smaller Clad-, Bosmina and Ceriodaphnia, in explaining the microfossil record of Frains Lake, Michigan.

Zooplankton populations in Libby Reservoir exhibit typical patterns found in most temperate lakes and reservoirs (Wetzel 1975), with maximum abundance in the spring and early summer, a decline throughout the summer and a slight increase in the fall (Figure 10). Daphnia abundances were greatest in the Canada area

Table 13. Zooplankton identified in water samples collected from Libby Reservoir, Montana, 1977 and 1978 (From Irving 1987).

Genera Species	Genera Species
<u>Alona sp</u>	<u>Daphnia</u>
<u>Bosmina longirostris</u>	<u>schodleri</u>
<u>Canthocamptus robertcokeri</u>	<u>galeata mendotae</u>
	<u>thorata</u>
<u>Chydorus sphaericus</u>	<u>Diaptomus tyrelli</u>
<u>thomasiCyclopsbicuspidatus</u>	<u>Epischura nevadensis</u>
	<u>Leptodora kindtii</u>

Table 14. Percent composition of major zooplankton genera present in Libby Reservoir, 1983 through 1987.

	1983	1984	1985	1986	1987
Daphnia	21.1	22.9	18.1	25.3	20.3
<u>Diaptomus</u>	37.1	15.1	28.9	31.5	19.6
<u>Cyclops</u>	40.6	52.4	46.1	42.5	55.1
<u>Bosmina</u>	1.1	9.3	6.7	0.4	4.9

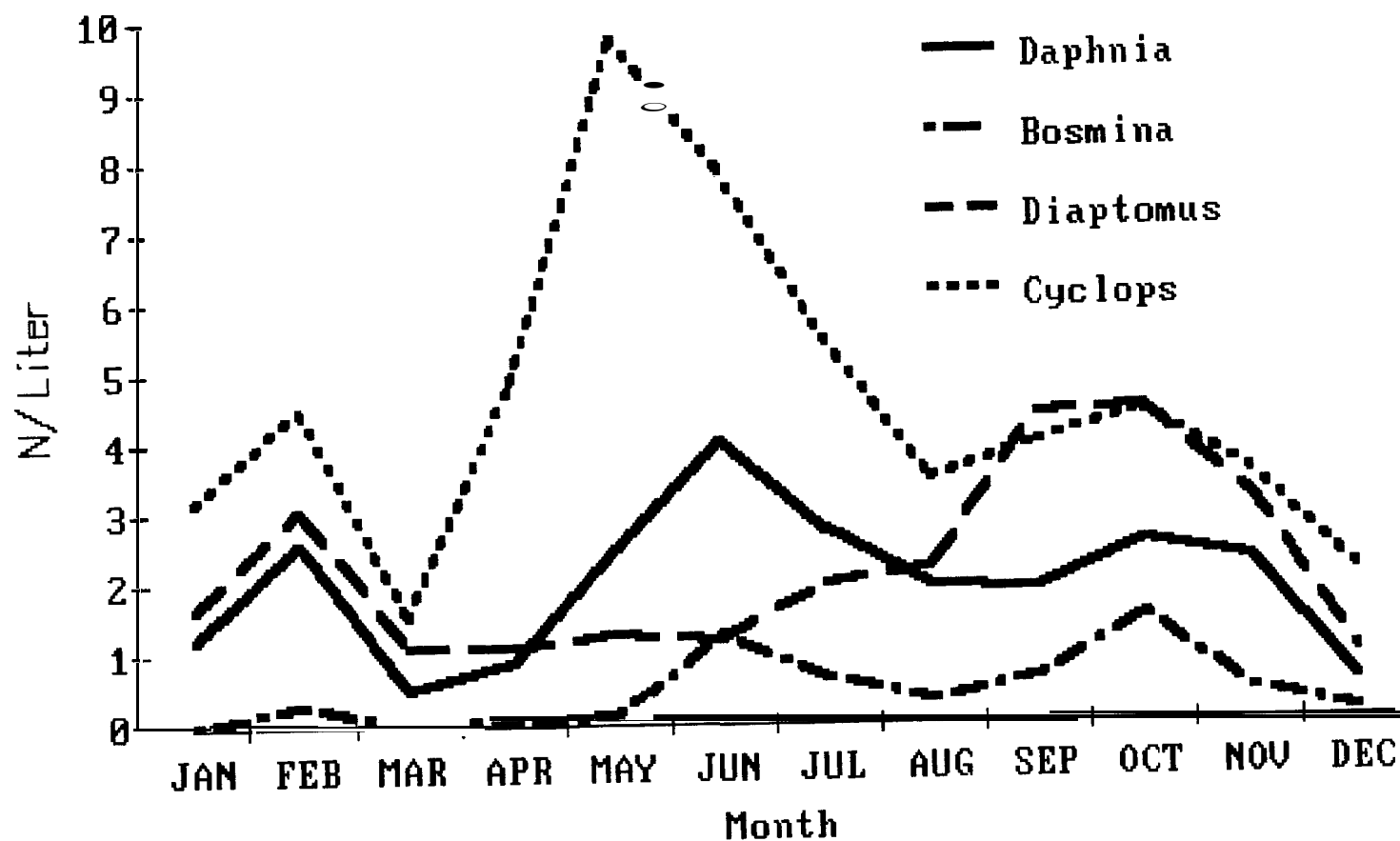


Figure 10. Seasonal abundance of the primary zooplankton genera in Libby Reservoir. Density has been averaged for each month for all samples collected from 1983 through 1987.

for all years sampled, with the exception of 1984 when a February sample taken in the Tenmile area contained 4.57 Daphnia per liter (Appendix D, Tables D1 through D18). Peak mean densities of Daphnia ranged between 4.31 and 10.47/l in the Canada area, 1.03 to 7.35/l in the Rexford area, and 1.63 to 4.76/l in the Tenmile area for the five years of sampling (ibid). In general, Daphnia densities peaked during May or June for all three areas, Cyclops densities peaked during April through June, and Diaptomus densities peaked in the fall, from September through November (Appendix D, Tables D1 through D18).

Zooplankton densities varied by area and year: statistical differences appeared dependent on the genera of zooplankton. Daphnia and Diaptomus densities were statistically greater in the Canada area than the Tenmile area, but only Daphnia densities were greater in the Canada area than in the Rexford area (Table 15). Greater nutrient input, faster spring warmup and less kokanee predation in the Canada area relative to the other areas may account for the difference. Water temperature, changing food conditions, and increased activity or abundance of predators were listed by Threlkeld (1979) as a hypothesis to explain Daphnia seasonality.

Overall Daphnia densities statistically differed between areas, but not between years. Bosmina, Diaptomus, Cyclops, and Epishura densities did vary through the years of sampling, however, as indicated in Table 15. Bosmina densities were highly variable, with all but years 1984 and 1985, 1983 and 1987, and 1985 and 1987 differing from each other. For Diaptomus, 1984 was the only year that differed from the rest; densities were lower in 1984 than all other years except 1987. Cyclops densities differed in 1983 and 1985 with densities in 1983 being the lowest of all years, all other year combinations were statistically similar. Because the sampling year in 1983 began in September (the project was first funded in May 1983), the large peak in Cyclops densities typically seen in May (Figure 10) was not detected. This bias probably accounts for the majority of the variation between 1983 and 1985.

While overall Daphnia densities did not statistically vary by year, the percent composition of Daphnia size classes did fluctuate (Figure 11). Notched box and whisker plots of the percent Daphnia in the 0.5- to 0.99-mm and 1.5- to 1.99-mm size class are presented in Appendix E, Figure E1 and E2. The notches provide an approximate 95 percent test of the null hypothesis that the true medians are equal (Chambers et al. 1983). From the plots it is apparent that the percent of small (0.5 to 0.99 mm) Daphnia was greatest in 1984 and 1985, when kokanee numbers were at their peak, and the lowest percent of large (1.5 to 1.99 mm) Daphnia also occurred during 1984 and 1985. The implication is that kokanee are exerting size-selective pressure on the Daphnia population. Other authors have found size-selective fish predation as a major influence on zooplankton community structure (Werner and Hall 1974, Zaret and Kerfoot 1975, Lynch 1979).

Table 15. Non parametric Tukey-type multiple comparisons for total zooplankton, Daphnia, and Diaptomus densities by study area and year. Between-area differences are indicated by different numbers: more than one number indicates similarity to both groups.

Area	Total Zooplankton	<u>Daphnia</u>	<u>Diaptomus</u>
Tenmile	1,2	1	1
Rexford	1	1	1,2
Canada	2	2	2

Year	Total Zooplankton	<u>Bosmina</u>	<u>Diaptomus</u>	<u>Cyclops</u>	<u>Epischura</u>
1983	1	1,2	1	1	1,2
1984	1,2	3	2	1,2	1
1985	2	3,4	1	2	2
1986	1,2	2	1	1,2	1
1987	1,2	1,4	1,2	1,2	1

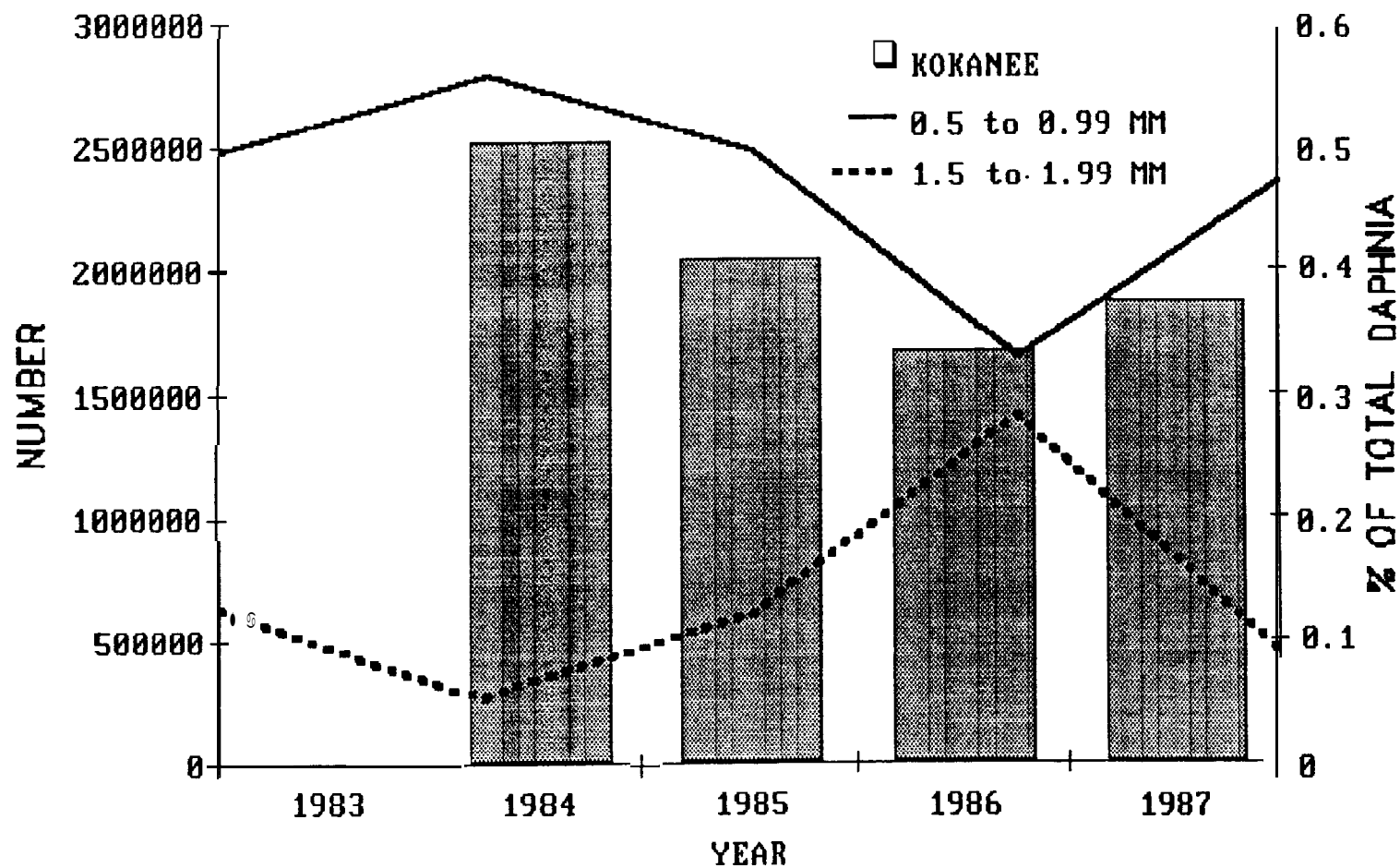


Figure 11. Comparison of estimated kokanee population size in Libby Reservoir and the relative percent of daphnia in the 0.5- to 0.00-mm and 1.5- to 1.99-mm size classes.

Results of our comparison of formalin-preserved zooplankton samples versus ethanol-preserved zooplankton samples indicated that no significant differences in mean length occurred (Table 16). A very slight difference in mean length of Daphnia existed: the Daphnia preserved in the formalin measured an average of 1.09 mm while the Daphnia preserved in ethanol measured 1.05 mm. This difference is felt to be negligible; however, further shrinkage may occur if samples are not processed within 3.5 months and this should be recognized.

#### Vertical Distribution

From September 1983 through September 1987, 920 Schindler trap samples were collected from Libby Reservoir. In addition, 216 Schindler trap samples were collected as part of a 48-hour diel series, in which the plankton (0- to 30-m depths) and water quality profile (0- to 48-m depths) in the Rexford area were monitored every two hours on July 20 through July 22, 1986.

The following discussion refers to the tables supplied in Appendix F. All species of zooplankton in Libby Reservoir exhibited some level of varying vertical distribution throughout the year. Generally, during the spring and summer months, depths from 12 to 30 m contained the lowest densities of each type of zooplankton and the 3- to 6-m depths contained the highest densities. Between October and March, densities at depth became more uniform throughout the water column. In all cases during the May through September period, densities found between the surface and 12 m were greater than densities found below 12 m.

The seasonal pattern of vertical distribution of Daphnia is presented in Figure 12. Shifts in the vertical distribution of zooplankton in Libby Reservoir detected by our daytime sampling are likely due to changes in water temperature and the depth of the euphotic zone and therefore availability of food. The relatively shallow depths (0 - 9 m) that zooplankton in Libby Reservoir seem to occupy during a majority of the spring and summer period may be a reflection of the annual turbidity cycle the reservoir experiences with refill. Zettler and Carter (1986) documented that many zooplankton species in Lake Temiskaming, Ontario-Quebec, displayed somewhat higher midday vertical distributions in turbid than in clear waters.

Daphnia exhibited a slight diel vertical migration pattern in the Rexford area during the summer of 1986 (Figure 13). A greater percentage of the Daphnia were found at the shallower depths (0-6 m) during late night and early morning hours than during daylight hours. The effect was most pronounced in the surface waters where 20 to 30 percent of the Daphnia were found during late night-early morning periods, but 0 to 10 percent were found during mid-afternoon periods. Daphnia densities were generally greatest at the 3-, 6-, and 9-m depths and densities from the 12- to 30-m depths were comparatively low and did not differ statistically. Daphnia apparently migrated to the surface during the late night

Table 16. Comparison of zooplankton lengths in samples preserved with formalin and with 95 percent ethanol. Samples were collected at the Tenmile area on December 18, 1986 and analyzed on March 30 and 31, 1987. Data is presented by number / mean length / standard deviation.

Sub-sample	Formalin			
	<u>Daphnia</u>	<u>Cyclops</u>	<u>Diaptomus</u>	<u>Epischura</u>
1	11/1.00/.31	27/.32/.06	4/.39/.09	2/1.28/.04
2	7/1.14/.10	35/.33/.08	12/.70/.77	- -
3	6/1.28/.30	32/.35/.09	12/.65/.27	1/1.35/.00
4	7/1.04/.18	30/.34/.06	14/.53/.24	- -
5	6/1.23/.12	37/.36/.10	11/.73/.29	- -
6	4/0.85/.30	39/.34/.08	8/.81/.26	- -
7	7/1.06/.30	29/.39/.12	11/.71/.28	- -
8	7/1.09/.34	33/.36/.09	14/.70/.29	- -
9	8/1.05/.30	38/.34/.08	10/.56/.24	- -
10	2/1.30/.21	26/.33/.07	6/.87/.23	- -
TOTAL	65/1.09/.27	326/.35/.09	102/.67/.27	3/1.30/.05
Ethanol				
1	10/1.08/.27	26/.38/.10	12/.66/.27	- -
2	12/1.10/.29	26/.37/.09	10/.82/.26	1/1.50/1
3	11/1.18/.17	32/.35/.09	11/.84/.25	- -
4	12/1.01/.28	37/.37 .08	12/.45/.12	- -
5	12/ .99/.22	34/.35/.07	6/.71/.25	- -
6	14/ .97/.28	26/.33/.10	14/.87/.26	1/1.30/1
7	9/1.07/.22	34/.35/.09	12/.66/.24	- -
8	12/1.00/.28	34/.36/.10	13/.60/.26	- -
9	9/1.09/.30	34/.34/.09	12/.47/.24	1/1.45/1
10	12/1.07/.28	26/.35/.08	9/.78/.26	- -
TOTAL	113/1.05/.26	314/.35/.09	111/.68/.28	3/1.42/.10

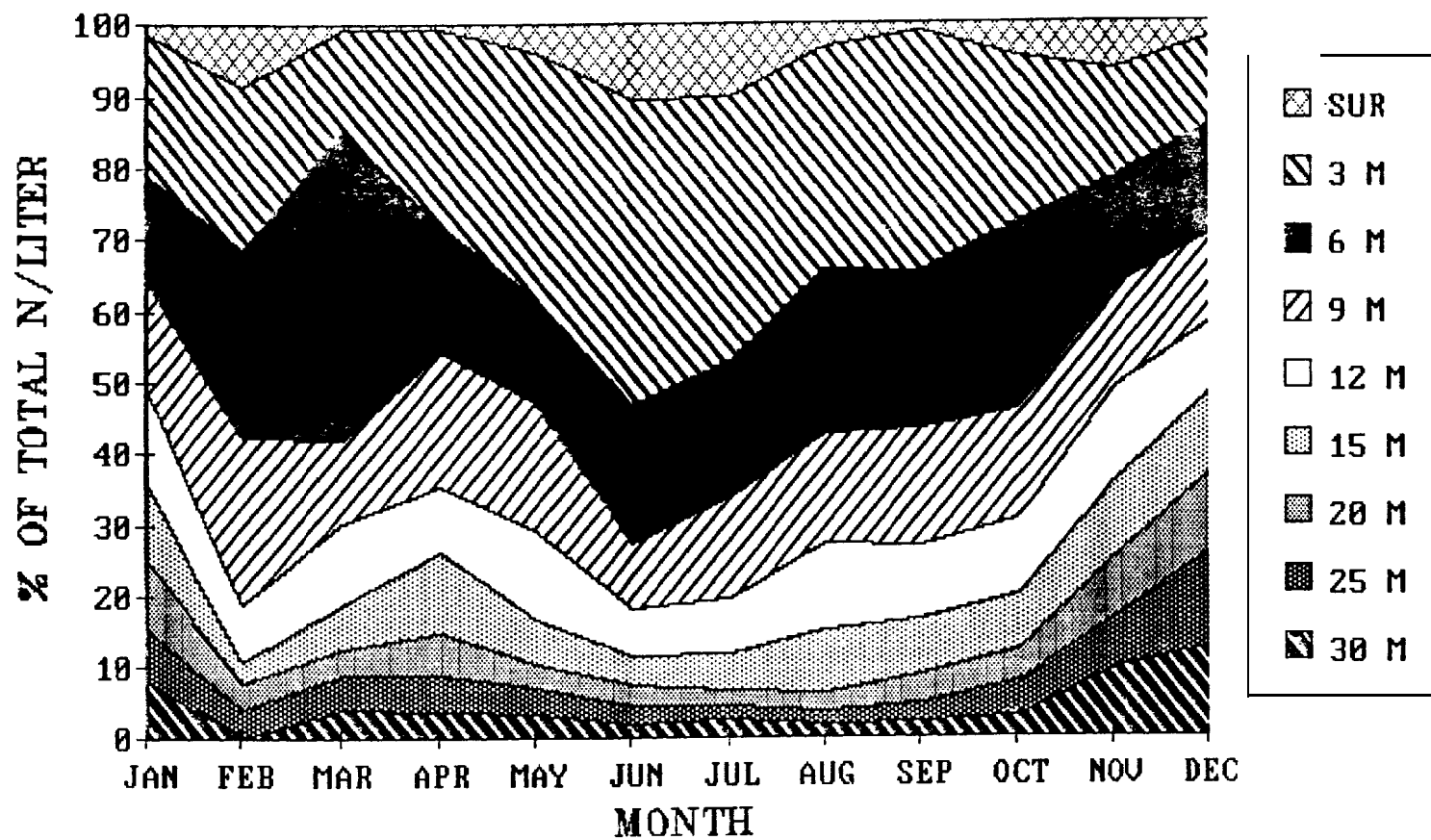


Figure 12. Seasonal vertical distribution of *Daphnia* in Libby Reservoir, all data combined, 1983 through 1987.

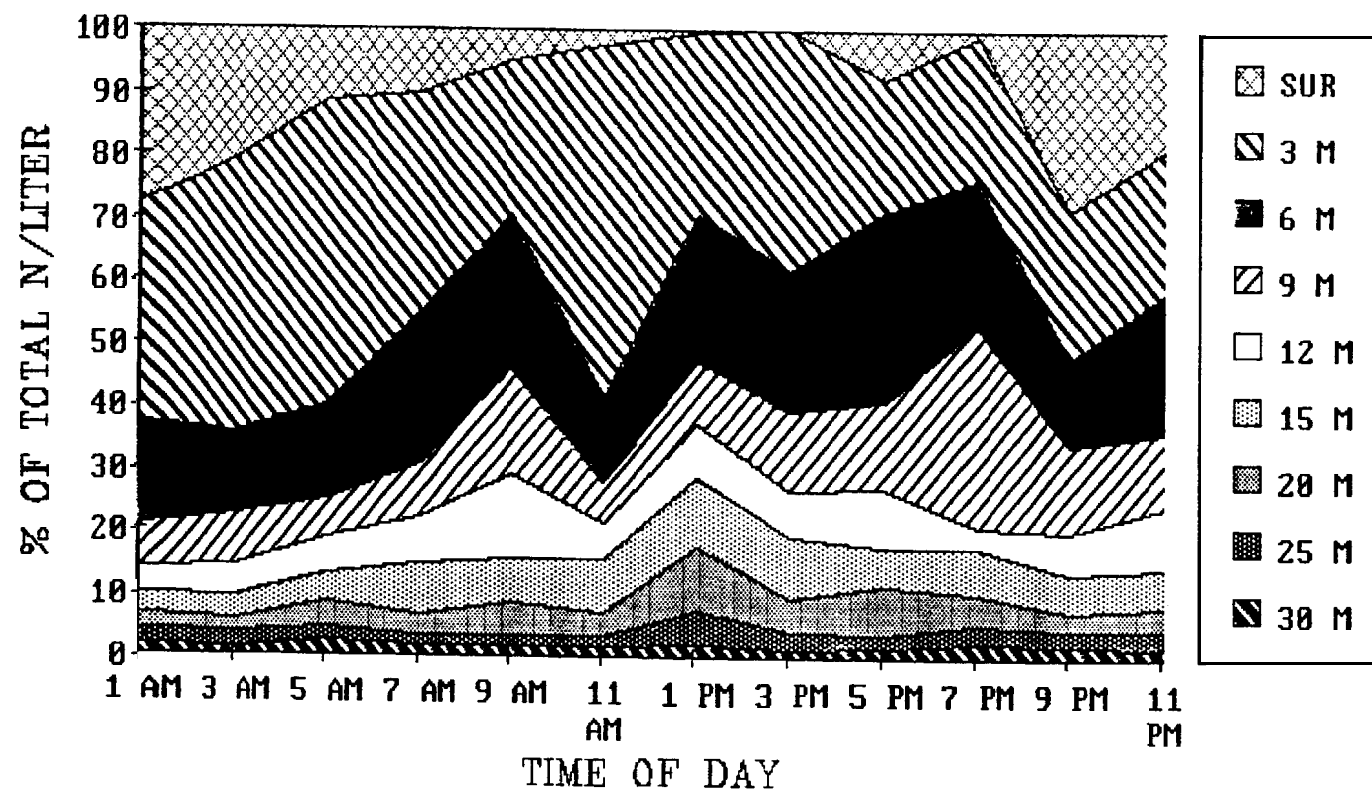


Figure 13. Diel vertical distribution of *Dapnnia* in the Rexford area of Libby Reservoir, July 21, 1986.

and early morning hours. Euphotic zone depth ranged from 2 to 10 m at the time of sampling. Water temperature averaged 10 C at 30 m, 16 C at 10 m and 20 C at the surface.

Three explanations for vertical migration of Daphnia are avoidance of sight feeding predators during daylight hours (Zaret and Suffern 1976), growth maximization by moving to cooler waters after feeding (the energetic or demographic hypothesis proposed by McLaren [1974]), and migration timed to crop the daily peak of primary production (Enright 1977). Each of these hypotheses could be applied to explain the diel migration of Daphnia illustrated in Figure 13. The increase in density at a depth of 3 m at 11:00 am was noted on both sampling days and may be an attempt to take advantage of the photosynthetic peak. The increase in density at 9 m during the 7:00 pm sampling occurred when surface temperatures were 24 C and the temperature at 9 m was 16 C. Orcutt and Porter (1983) concluded that maximum fitness is achieved by Daphnia remaining at the warmest surface waters at all times, refuting McLaren's (1974) hypothesis. Conclusions as to the mechanism involved in Daphnia diel vertical migrations at Libby Reservoir are not possible, based on our sampling methods. However, this type of data has important implications, particularly when interpreting or applying zooplankton data sets to dam operation.

## **TERTIARY PRODUCTION**

F I S H -

### **Methods**

Rainbow and cutthroat trout field identifications were based on scale size, presence of basibranchial teeth, spotting pattern and presence of a red slash on each side of the jaw along the dentary. We recognize the difficulty in distinguishing between rainbow, cutthroat and their hybrid using morphometric characteristics as reported by Leary et al. (1983), and where appropriate have grouped the two species.

Abbreviations used throughout this report for the various species of Libby Reservoir are as follows: rainbow trout (RB), westslope cutthroat trout (WCT), rainbow x cutthroat hybrids (HB), bull trout (DV), kokanee salmon (KOK), mountain whitefish (MWF), burbot (LING), peamouth (CRC), northern squawfish (NSQ), redbelt shiner(RSS), largescale sucker(CSU), longnose sucker(FSU), and yellow perch (YP).

### **Seasons**

The year was stratified into four seasons based on reservoir operation and surface water temperature criteria for gillnetting:

- 1) Winter (January -March), the reservoir was being drawn down, surface water temperatures dropped below 8°C;
- 2) Spring (April - June), the reservoir was refilled, surface water temperatures increased to 9 - 13°C;
- 3) Summer (July- September), the reservoir was held at full pool, surface water temperatures increased to above 17°C and;
- 4) Fall (October - December), drafting of the reservoir began, surface water temperature dropped to 13 - 9°C

### **Nearshore Zone Fish Abundance**

Seasonal and annual changes in fish abundance within the nearshore zone were assessed using floating and sinking horizontal gill nets. These nets were 38.1-m long and 1.8-m deep and consisted of five equal panels of 19-, 25-, 32-, 38-, and 51-mm mesh.

One to seven "double-floating" (two nets tied together end to end) and two sinking gill nets were set in the spring and fall. Nets were set perpendicular from the shoreline just before sunset and were retrieved shortly after sunrise. All fish were removed from the nets, and species, length, weight, sex and state of

maturity were recorded. Scales, stomach samples and a limited number of otoliths were collected for age and growth analysis.

A spring sinking and fall floating gillnetting series have been used by the MDFWP since 1975 to assess annual trends in fish abundance. These yearly sampling series were continued using criteria established by Huston et al. (1984). Numbers of fish caught per net between 1975 and 1982 were compared by Huston et al. (1984) by the Kruskal-Wallis ranking test, and were used in this report. Catch rates during the period from 1983 through 1987 were log transformed and tested for significant differences at the five percent level using analysis of variance.

### **Limnetic Zone Fish Abundance**

Vertical gill nets were used to assess the relative abundance and depth distribution of fish species in the limnetic zone of each area. An overnight set of four 45.7-m deep by 3.7-m wide vertical gill nets of mesh sizes 19, 25, 32 and 38 mm was made monthly in each area. Each net was marked at 1-m intervals. As the vertical nets were retrieved, fish were removed and depth of capture, species, length, weight, sex, and state of maturity were recorded, and scale samples and fish stomachs were collected. Relative abundance of the various fish species in the limnetic and nearshore zones were compared using vertical and horizontal gillnetting data.

## **Results and Discussion**

### **Nearshore Zone**

In the period 1983 to 1987, 742 floating and 198 sinking gill nets were set, capturing 28,228 and 11,364 fish, respectively. A total of 13 species of fish were captured, three of which represented over 70 percent of the catch on most sampling dates.

Notable changes in the assemblage of fish species in Libby Reservoir have occurred since impoundment in 1972. Two new species, kokanee and yellow perch, are present that did not occur in the Kootenai River prior to impoundment. Kokanee were released into the reservoir from the Kootenay Trout Hatchery in British Columbia, and yellow perch may have dispersed into the reservoir from Murphy Lake (Huston et al. 1984). Peamouth and northern squawfish were rare in the Kootenai River before impoundment, but have increased in abundance in the reservoir. Mountain whitefish, rainbow trout, westslope cutthroat trout and redbside shiner were all common in the Kootenai River before impoundment but have decreased in abundance since impoundment. Two predacious species, bull trout and burbot, were uncommon in the Kootenai River before impoundment, and subsequent gill net catches show no clear population trends. More detailed descriptions of changes in gill net catches since 1972 are given below.

### Peamouth

Peamouth were considered by Huston et al. (1984) to be rare in the Kootenai River before ~~impoundment~~. Since 1979 they have been the most abundant fish captured in the fall gillnetting series, with the exception of 1985 when kokanee were numerically dominant (Table 17 and Appendix G, Tables G1 - G13). The upward trend in catch rate has been consistent over time, except between 1983 and 1985. During the 1985 sampling period, water temperature was 4.80C colder than average temperatures during fall sampling in previous years, and nets were set 32 days later. Colder water may have caused peamouth to be farther offshore, or to be less active and therefore less vulnerable to gillnetting. If so, 1985 catches were not a valid indication of ~~population~~ decline. The population structure of the 1985 catch was composed of more distinct age classes than were present in other years (Figure 14). The much larger catch in 1987 was dominated by a single year class (Figure 15).

Increases in catch of peamouth between 1978 and 1982 were significant ( $p > 0.01$ ) by the Kruskal-Wallis ranking test (Huston et al. 1984), and increases between 1983 and 1987 were significant ( $p < 0.05$ ) by ANOVA.

### Kokanee

Kokanee were the second most abundant fish captured in the fall gillnetting series (Table 17 and Appendix G, Tables G1 - G13). Fluctuations in catch rate occurred annually according to the strength of various year classes. The first captures of Kokanee were made in 1979. Large numbers of kokanee were caught in 1982, most of which were ascertained by Huston et al. (1984) to be the result of an accidental release of 250,000 fry in 1980 from the Kootenay Trout Hatchery in British Columbia. Reproduction by these fish resulted in the large spawning population in 1985 which consisted of a single size class (Figure 16). The smaller catch in 1986 consisted of two distinct size classes (Figure 17) spawned in 1983 and 1984.

### Yellow Perch

Yellow perch were first caught in the spring sinking gill nets in 1982, and each year thereafter the catch rate increased (Table 18 and Appendix G, Tables G1 - G13). The annual increases after 1985 were statistically significant ( $p < 0.05$ ). The barren and heavily eroded shoreline of Libby Reservoir is unlike the debris or vegetation-covered substrate preferred by yellow perch for spawning (Scott and Crossman 1973). Based on the rate of increase of yellow perch since 1982, lack of spawning habitat does not yet appear to be limiting their abundance.

### Mountain Whitefish

Mountain whitefish have shown a dramatic decline from their abundant status in the Kootenai River before impoundment to a

Table 17. Average catch per net in floating gill nets set during the fall in the Tenmile and Rexford areas of Libby Reservoir, 1975 through 1987. <sup>a/</sup>

Parameter	Year										
	1975	1976	1978	1979	1980	1982	1983	1984	1985	1986	1987
Surface temperature	16.1	17.2	15.6	16.7	15.6	16.7	16.3	15.6	11.4	14.9	17.7
Date	9/23	9/23	9/20	10/2	10/1	9/22	9/16	9/25	10/24	9/22	9/20
Number of nets	129	91	78	73	79	70	24	28	40	58	58
Reservoir elevation		2458	2458	2447	2455	2457	2456	2451	2434	2445	2446
Average catch of: <sup>b/</sup>											
RB	2.8	3.6	6.3	4.9	4.8	2.4	1.9	1.5	2.5	1.9	0.7
WCT	2.0	2.5	2.0	1.4	1.2	1.2	0.7	0.7	1.4	0.6	0.2
RB x WCT <sup>c/</sup>	0.0	0.0	0.1	<0.1	<0.1	<0.1	1.6	0.4	1.0	1.6	0.8
SUB-TOTAL	4.8	6.1	8.4	6.3	6.0	3.6	4.2	2.6	4.9	4.1	1.7
MF	2.0	2.3	1.2	1.4	0.6	1.0	0.4	0.8	0.2	0.8	0.1
ax!	4.0	4.2	3.0	6.5	8.8	15.1	12.6	11.0	5.5	17.5	40.1
NSQ	4.2	4.7	4.2	2.1	1.9	3.5	1.9	1.3	0.5	1.5	1.3
RSS	3.3	7.9	7.3	2.0	0.5	0.2	0.7	0.2	0.1	0.2	0.4
DV	<0.1	<0.1	43.1	0.1	0.2	<0.1	0.0	0.1	0.2	0.1	0.0
CSU	1.9	2.4	0.9	1.1	1.2	1.2	0.4	0.2	0.1	0.2	0.1
KCK	0.0	0.0	0.0	0.2	0.0	7.1	0.3	6.5	8.1	3.4	5.7
TOTAL	20.2	27.6	25.0	19.7	19.2	31.7	20.5	22.7	19.6	31.9	51.1

<sup>a/</sup> Catches prior to 1983 reported by Huston et al. (1984).

<sup>b/</sup> Abbreviations explained in "Methods" section under "Fish Abundance."

<sup>c/</sup> Prior to 1983, very few hybrids were identified as such, although they were probably present in the samples.

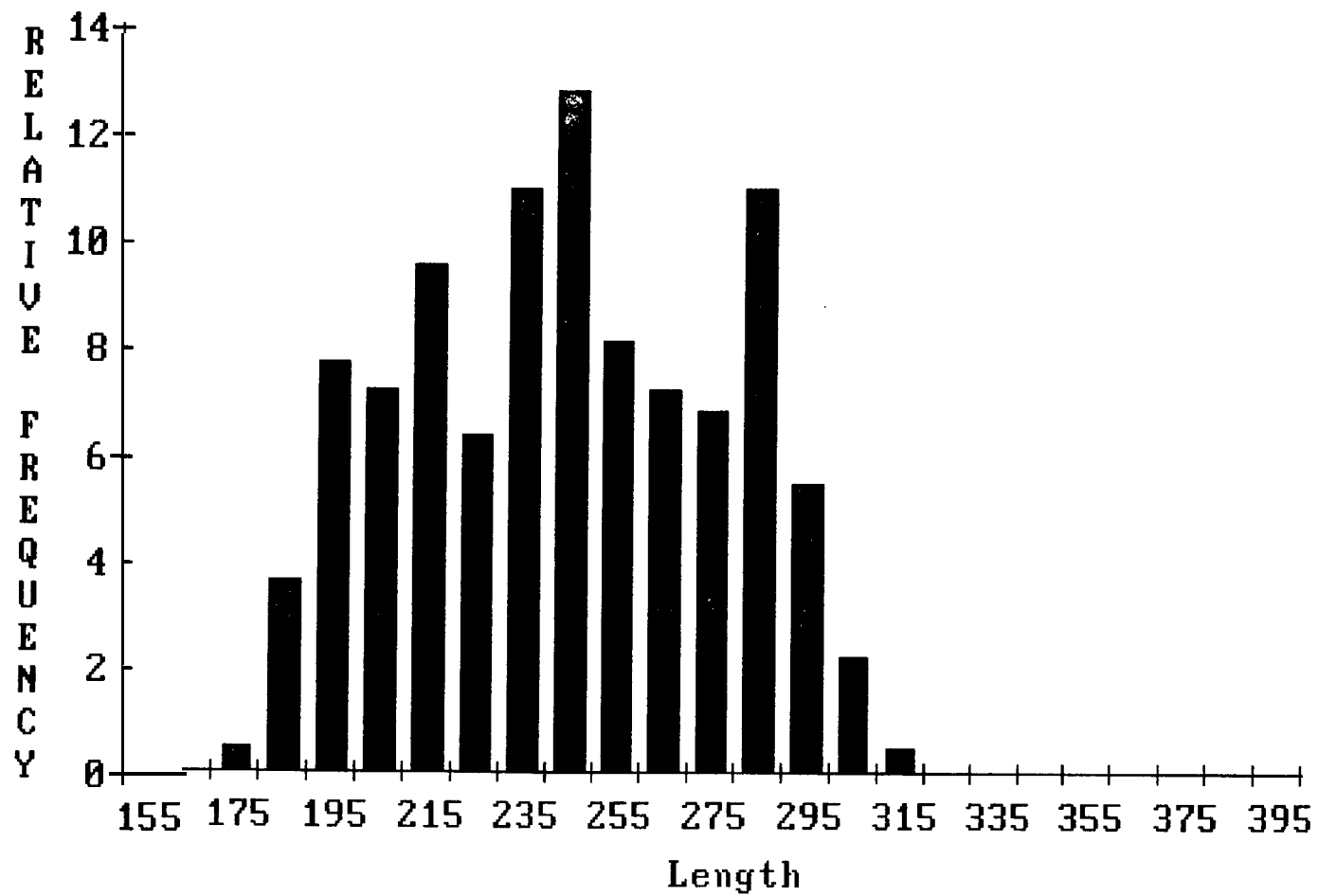


Figure 14. Length-frequency distribution of peamouth captured in fall gill nets in Libby Reservoir, 1985.

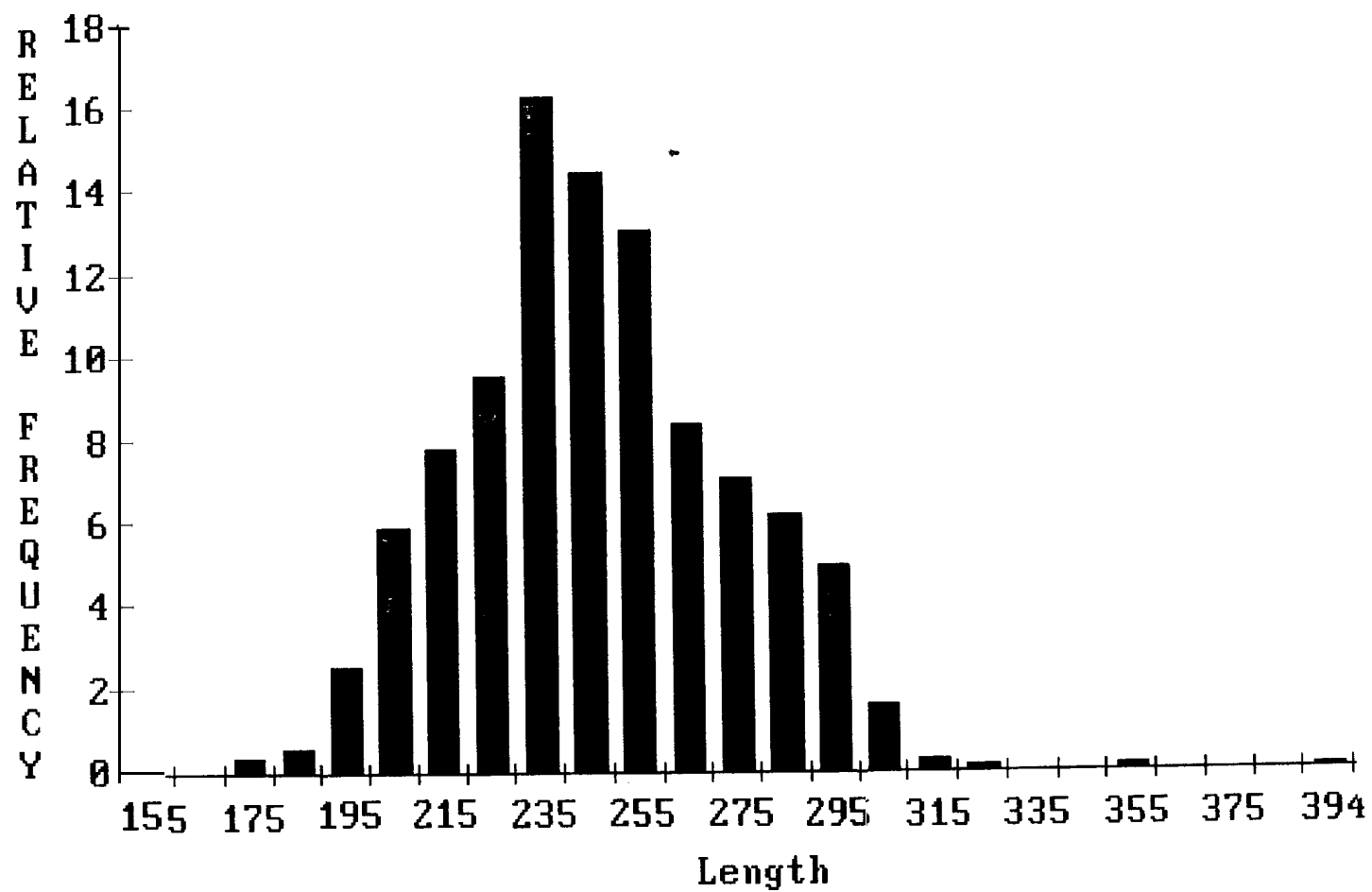


Figure 15. Length-frequency distribution of peamouth captured in fall gill nets in Libby Reservoir, 1987.

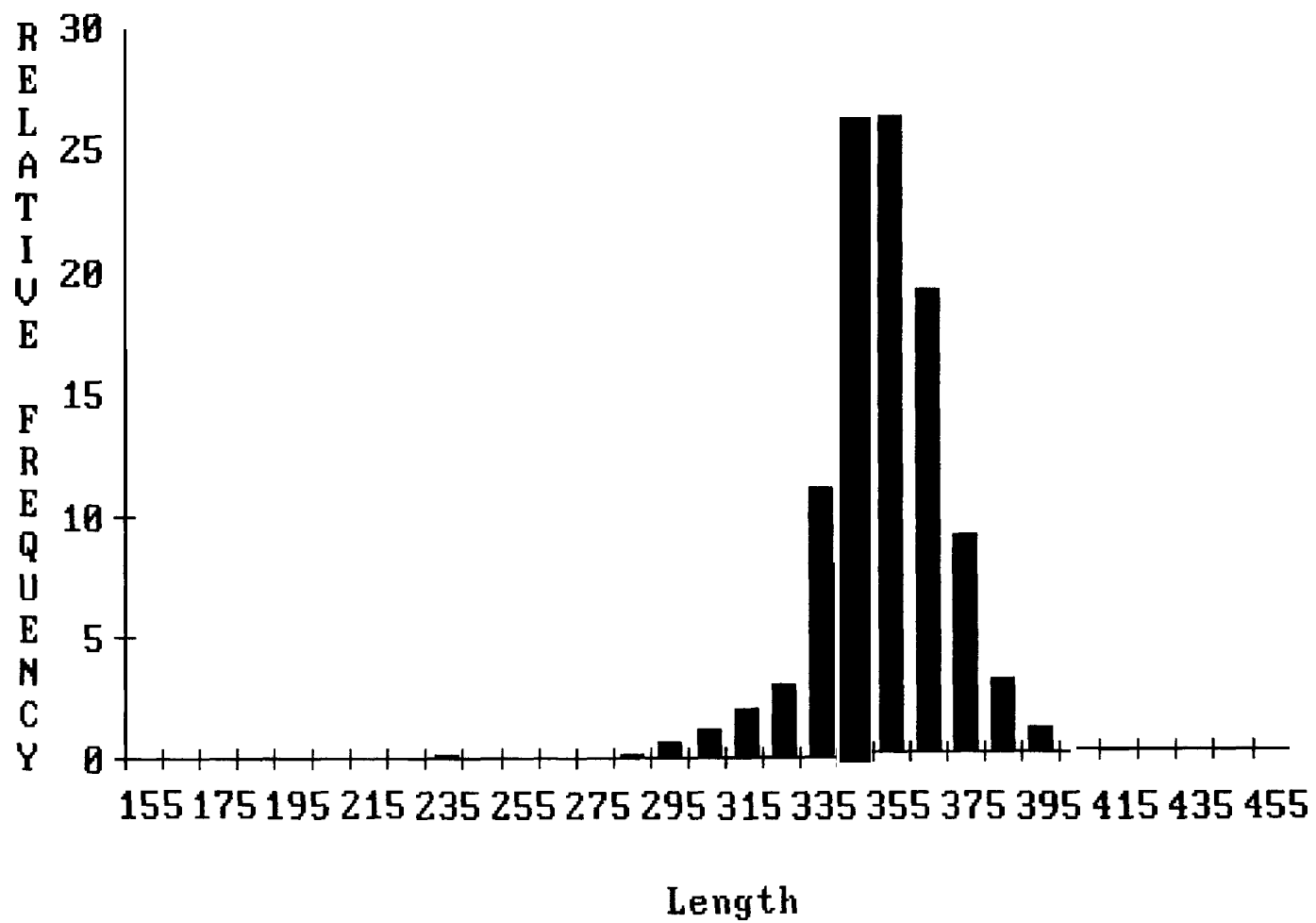


Figure 6. Length-frequency distribution of kokanee captured in spring gill nets in Libby Reservoir, 1985.

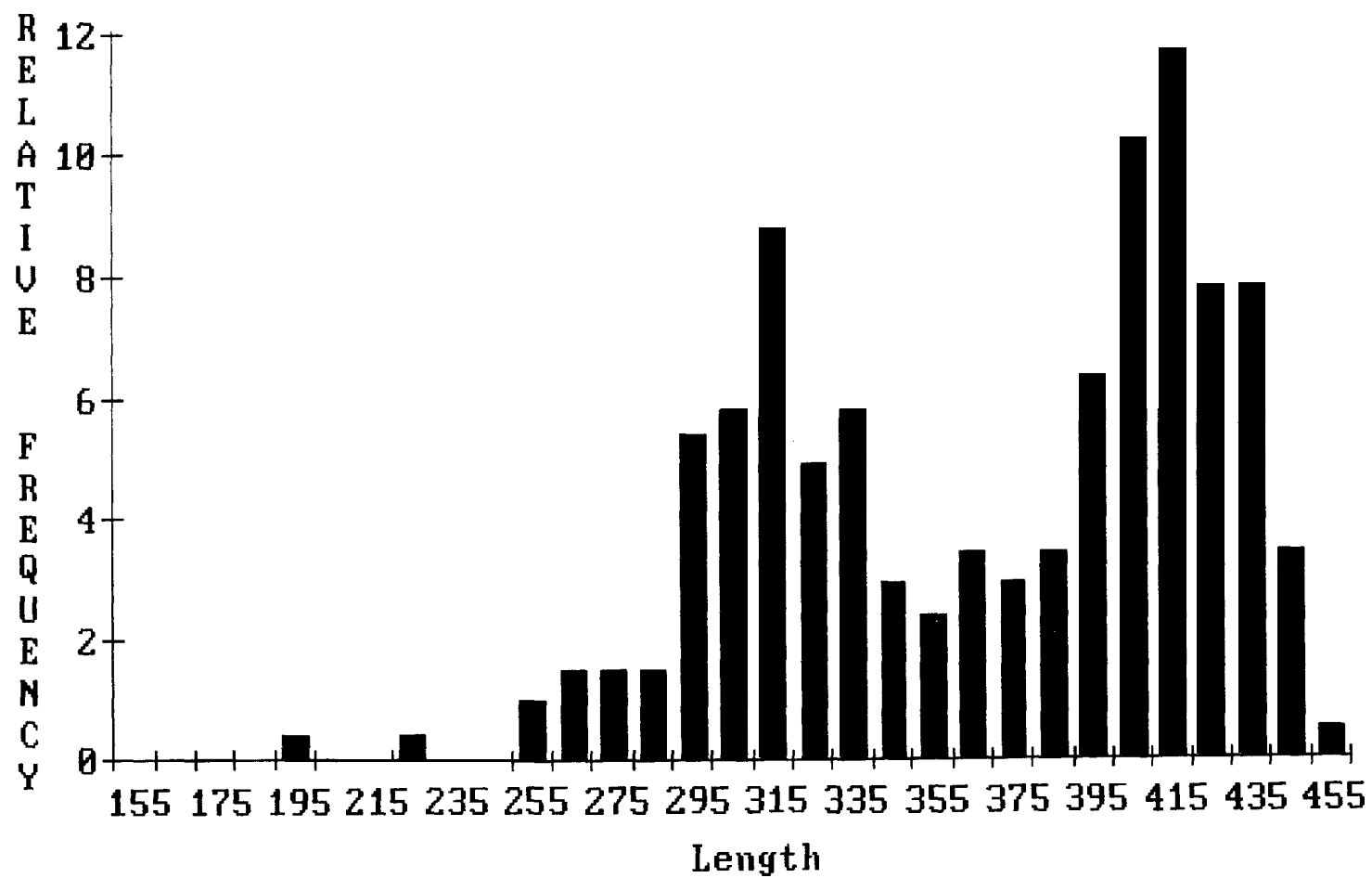


Figure 17. Length-frequency distribution of kokanee captured in spring gill nets in Libby Reservoir, 1986.

Table 18. Average catch per net in sinking gill nets set during the spring in the Rexford area of Libby Reservoir, 1975 through 1987.<sup>a/</sup>

Parameter	Year								
	1975	1976	1978	1980	1982	1984	1985	1986	1987
Surface									
temperature	12.8	12.2	11.1	11.1	11.7	12.7	15.0	11.9	10.8
Date	6/9	5/18	5/15	5/5	5/25	6/12	6/6	5/8	5/5
Number of nets	111	41	41	38	36	20	23	28	28
Reservoir									
elevation		2373	2367	2389	2363	2412	2415	2379	2390
Average catch of: <sup>b/</sup>									
FB	0.8	0.3	1.4	0.7	1.4	2.5	0.3	0.2	1.5
WCT	0.2	0.4	0.4	0.2	0.4	<0.1	0.1	0.0	0.4
FB x WCT <sup>c/</sup>	0.0	0.0	0.0	0.0	<0.1	0.6	0.1	<0.1	0.6
CRC	66	64	72	LO	21	29	08	58	23
NSQ	23 0.3	1.0	0.7	7.2	24.3	59.2	79.7	39.2	25.5
.		1.2	5.8	2.8	4.3	8.0	8.9	5.5	9.1
RSS	0.7	1.4	2.8	0.7	1.9	2.5	1.4	0.1	0.4
DV	1.4	1.9	2.2	0.8	1.5	1.8	1.3	1.9	1.2
LING	<0.1	0.2	0.3	0.6	0.5	0.4	0.6	0.7	0.9
CSU	37.3	26.1	23.5	36.3	18.6	30.2	21.3	8.3	8.5
FSU	7.9	11.1	9.1	5.8	10.9	5.6	4.3	1.5	1.8
YP	0.0	0.0	0.0	0.0	0.2	0.8	1.0	2.6	5.5
TOTAL	56.8	50.0	53.4	56.1	66.0	114.5	119.8	66.5	55.7

<sup>a/</sup> Catches prior to 1984 reported by Huston et al. (1984).

<sup>b/</sup> Abbreviations explained in "Methods."

<sup>c/</sup> Prior to 1984, very few hybrids were identified as such, although they were probably present in the samples.

<sup>d/</sup> Numbers of redbreasted shiners were not recorded in 1975, a 1 -  
- m m @ .

level of only 2.3 captures per sinking gill net set in the spring of 1987 (Table 18 and Appendix G, Tables G1 - G13). Catches in the initial years following impoundment were high, possibly due to the remnant population from the Kootenai River. Catches in sinking gill nets after 1978 were lower and more variable, ranging from 0.8 in 1985 to 5.8 fish per net in 1986. Lack of suitable spawning habitat in tributaries and the loss of the spawning substrate within the old Kootenai River channel may be the primary factors contributing to the decline of whitefish in Libby Reservoir.

#### Rainbow and Westslope Cutthroat Trout

Rainbow and westslope cutthroat trout captures in fall gill nets have both declined gradually since 1978 (Table 17 and Appendix G, Tables G1 - G13). High capture rates occurred for both species in the initial years of impoundment, although rainbow captures have been consistently greater than cutthroat captures. Kruskal-Wallis ranking tests showed a significant ( $p < 0.01$ ) decline in catch of both species from 1978 to 1982 (Huston et al. 1984). Analysis of variance of the catches in 1983 and 1987 also showed significant ( $p < 0.05$ ) differences. In both species, the causes for decline probably include reductions in planted stock, limited spawning habitat in tributary streams, and competition with the abundant planktivores in the reservoir. Rainbow abundance may also be detrimentally affected by the reduction in reidside shiner abundance, which McMullin (1979) found to be a primary prey item of rainbow trout in Libby Reservoir.

#### Redside Shiner

Redside shiner captures in fall gill nets indicated a decline similar to that shown by whitefish and trout species. Shiners, although restricted to slow water habitats, were common in the Kootenai River before impoundment. Captures in Libby Reservoir were high in the first years after impoundment, possibly due to hold-overs from the Kootenai River, but since 1980 have averaged fewer than one fish per net in every year sampled (Table 17 and Appendix G, Tables G1 - G13). Spawning substrate for reidside shinners, which consists of flooded vegetation, may have been available in the first years after impoundment and facilitated successful reproduction in those years. Extensive shoreline erosion in subsequent years probably eliminated suitable spawning substrate and may now be the primary factor limiting reidside shiner abundance.

#### Bull Trout

Bull trout captures in the fall gillnetting series were low, probably because sampling coincided with the period in which adults were in the spawning tributaries. Captures in the spring varied between years without any statistically significant trend upward or downward (Table 18 and Appendix G, Tables G1 - G13). Mountain whitefish were found to be the primary food item in the stomachs of bull trout in Hungry Horse Reservoir (May et al. 1988)

and Flathead Lake (Leathe and Graham 1982). Huston et al. (1984) found the catch of bull trout in Libby Reservoir to increase and decrease with the catch of mountain whitefish, and this same trend has persisted from 1984 to 1987. This relationship may be coincidental for two reasons: 1) the changes in bull trout numbers from 1984 to 1987 were not statistically significant ( $p < 0.05$ ); and 2) bull trout populations, being made up of several age classes, should have a delayed response to fluctuations in their prey base. Analyses of stomach contents of bull trout captured in Libby Reservoir between 1983 and 1987 show they are successfully utilizing most prey species other than mountain whitefish (Table 42).

#### Northern Squawfish

Northern squawfish were rare in the Kootenai River before impoundment, yet were one of the more abundant fish in both spring and fall gill nets in the first years following impoundment (Table 17 and Appendix G, Tables G1 - G13). Spring catches have shown a modest decline over time, while fall catches have shown an increase from 2.3 fish per net in 1975, to 9.1 fish in 1987.

#### Largescale Sucker

Largescale suckers were abundant in the Kootenai River before impoundment, and dominated catches in spring sinking gill nets set between 1975 and 1984 (Table 18 and Appendix G, Tables G1 - G13). Catches in 1986 and 1987 fell dramatically, and in both years were significantly lower ( $p < 0.05$ ) than in 1984 and 1985. Prior to 1986, spring sampling was done in the first or second week of June, and in 1986 and 1987 was done in the first week of May. This change in date of sampling probably accounts for the change in capture rate after 1985.

A single dominant size class of largescale suckers averaging about 375 mm comprised the 1984 and 1985 sinking gill net samples (Figure 18). The smaller catches in 1986 and 1987 consisted of several well defined size classes (Figure 19). The single size classes of 1984 and 1985 may have been spawning adults and the larger catch rates in 1984-85 than in 1986-87 may be the result of greater vulnerability of spawners that were enroute to shoreline or tributary spawning areas. Unlike the catches preceding 1986, the multiple size classes of 1986 and 1987 are assumed to be representative of the population structure of fish greater than 150 mm. The decline in catch rate in 1986 and 1987 is not considered to be a valid indication of the population trend.

#### Longnose sucker

Longnose suckers were uncommon in the Kootenai River before impoundment. In Libby Reservoir, longnose suckers were generally caught only in spring sinking gill nets. The highest catch rate was attained in 1976 when 11.1 fish per net was caught: the lowest catch rate was in 1986, when only 1.5 fish per net were caught (Table 18). The change in date of sampling after 1985 is assumed

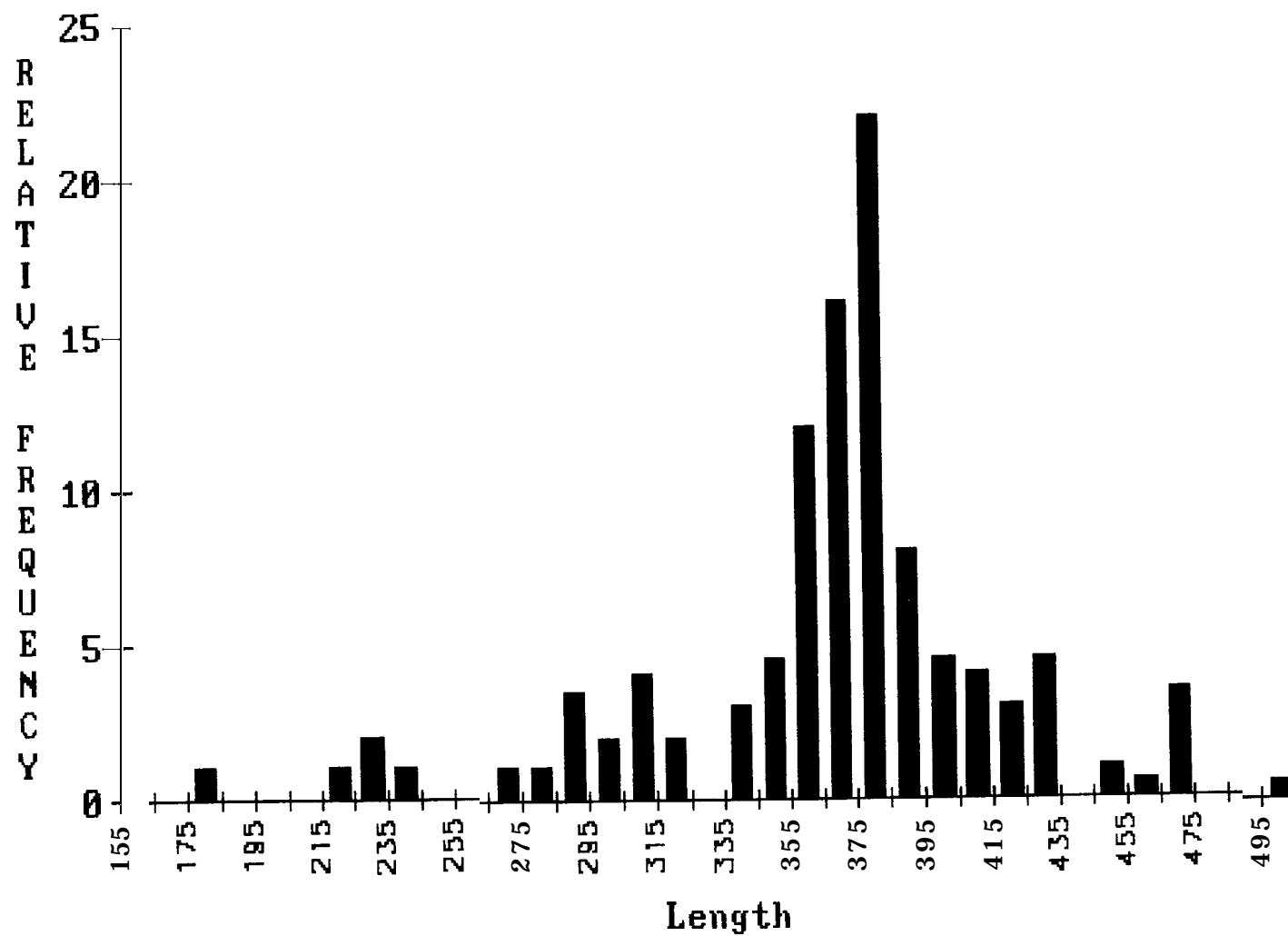


Figure 18. Length-frequency distribution of largescale suckers captured in spring gill nets in Libby Reservoir, 1984 and 1985.

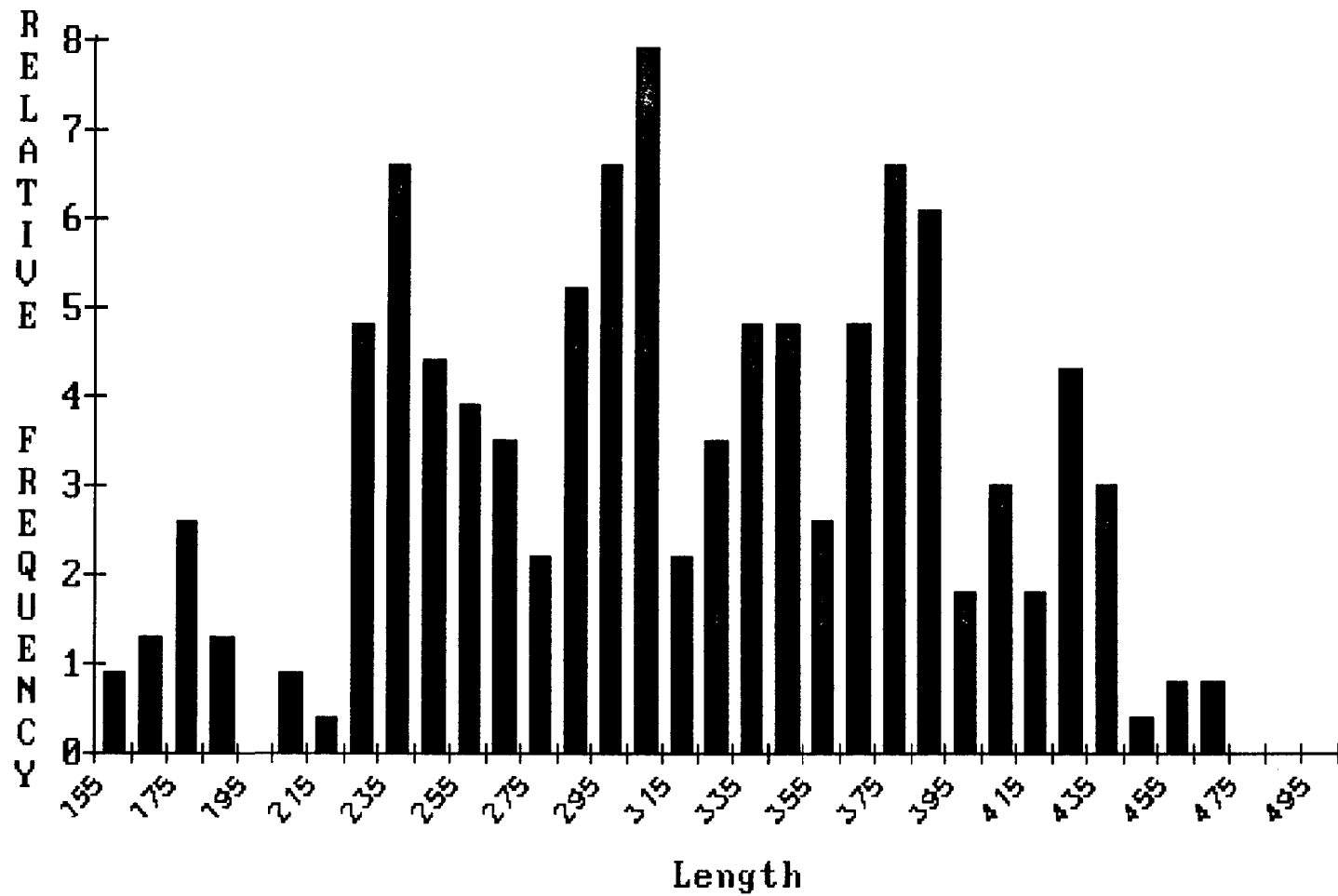


Figure 19. Length-frequency distribution of largescale suckers captured in spring gill nets in Libby Reservoir, 1986 and 1987.

to affect the catch of longnose suckers just as it did the catch of largescale suckers, and is not considered an indication of decline in the population.

#### Burbot

Burbot were uncommon in the Kootenai River before impoundment. Catches in spring sinking gill nets were small in the first years following impoundment and have gradually increased to a high of 0.9 burbot per net in 1987 (Table 18). Differences in catch rate at the 0.05 level of significance exist only between the years of 1983 and 1987. Analyses of stomach contents of burbot caught between 1983 and 1987 have shown largescale suckers to be a heavily used prey item. The abundance of largescale suckers and increasing numbers of yellow perch (another important prey item) may have contributed to the increase of burbot.

#### Total Fish Abundance

The average total catch of fish in the floating gill nets set in the fall was fairly constant between 1975 and 1985. Large catches of 27.6 and 31.7 per net fish occurred in 1976 and 1982, respectively, while in other years the catch was consistently around 20 fish per net. In 1986 the catch increased to 31.9 and in 1987 to 51.1 fish per net, solely due to increases in peamouth.

The average total catch of fish per sinking gill net set in the spring varied little between 1975 and 1980, ranging from 50 to 56.8 fish per net. After 1980, catches increased substantially until 1985 when catches peaked at 119.8 fish per net. Catches in 1986 and 1987 dropped to half the size of the 1985 catch. The drop in total catch in 1986 and 1987 is not considered to be a valid indication of the population trend due to the change in sampling schedule described earlier. Catostomus spp. and peamouth accounted for most of the decline in 1986 and 1987. Both species are more susceptible to gillnetting in June than May because of spawning activity in June.

The relative frequencies of species captured in the spring sinking gill net series are shown in Figure 20. Five species of fish dominated the catch, comprising over 90 percent of the assemblage. Peamouth had the greatest relative abundance for all years, but since 1985 their relative abundance has decreased due to increasing numbers of northern squawfish and yellow perch. The relative percentage of Catostomus spp. in the catch remained relatively constant from 1984-1987, while the relative abundance of mountain whitefish varied greatly, ranging from less than 17 percent of the total catch in 1985 to 9 percent in 1986.

The relative frequencies of species caught in the floating gill net series set in the fall are given in Figure 21. Peamouth chubs had the highest relative abundance in all years except 1985 when they were displaced by a large year class of kokanee. The catch rate of northern squawfish remained relatively constant over

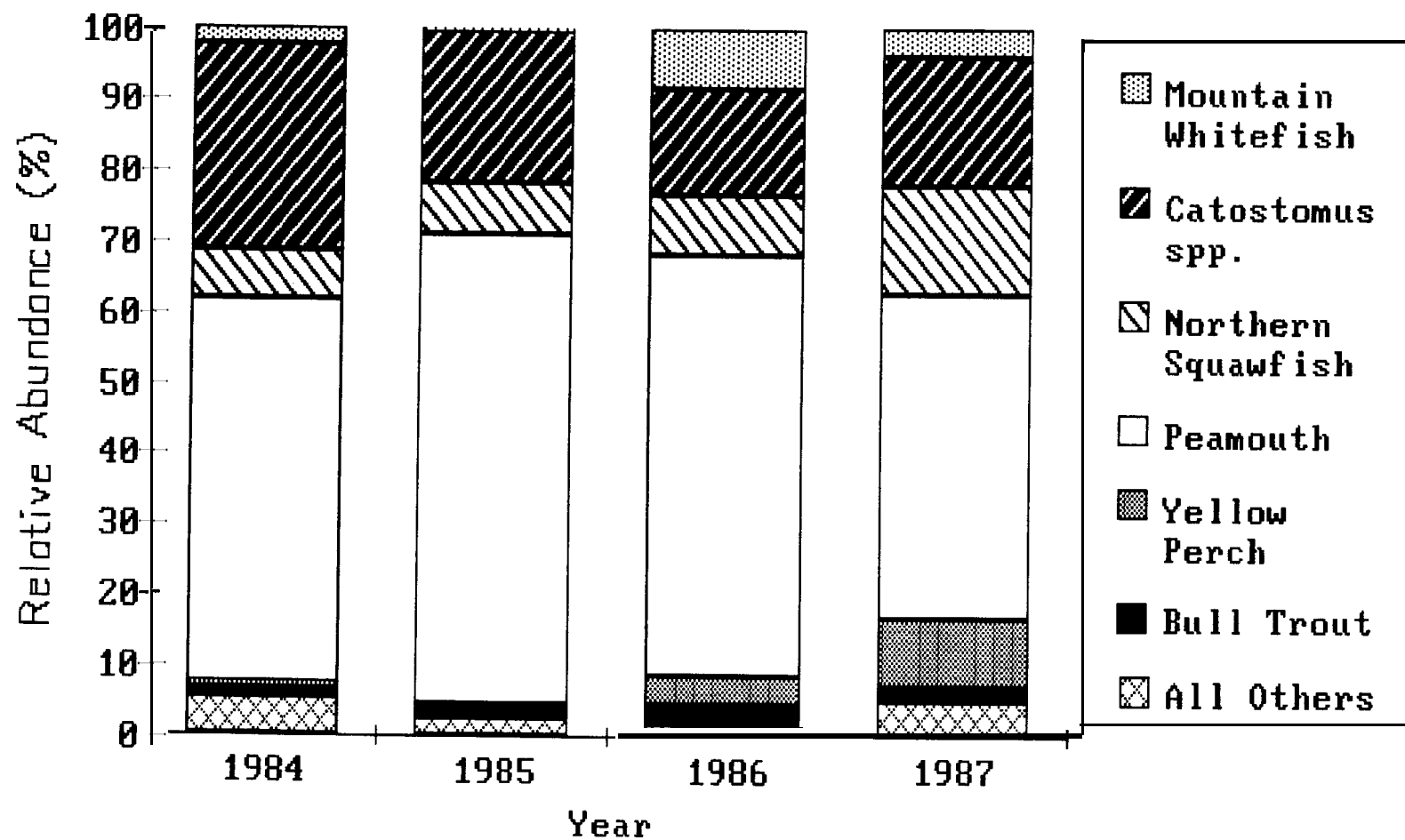


Figure 20 Relative abundances of fish species caught in sinking gill nets in the spring in Libby Reservoir, 1984 through 1987.

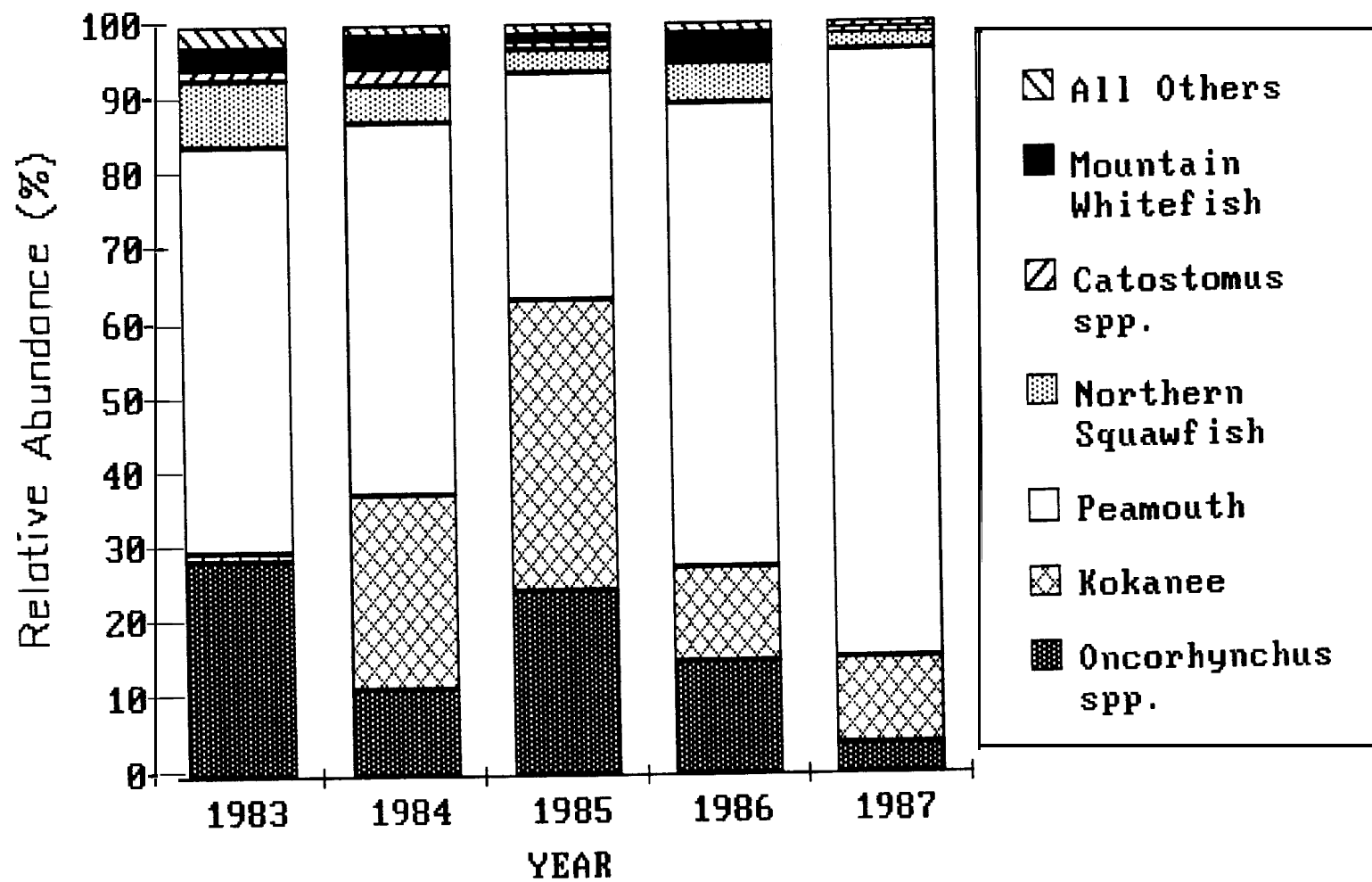


Figure 21. Relative abundances of major fish species caught in floating gill nets set in the fall in Libby Reservoir, 1983 through 1987.

the sampling period, but its relative abundance declined due to the increase in peamouths. In addition, the relative abundance of Oncorhynchus trout species declined over the time period.

Changes in the assemblage of fish species in Libby Reservoir are similar to changes that have occurred in other reservoirs. The classic process of reservoir aging is initiated by a period of trophic disequilibrium as basin filling begins, and is eventually followed by a period of equilibrium (Kimmel and Groeger 1986). Disequilibrium is characterized by "trophic upsurge and depression" (Baranow 1961). Fluctuations in fish populations occur during the disequilibrium phase, but usually stabilize within 5 to 10 years (Kimmel and Groeger 1986). Trout species and mountain whitefish, common in the Kootenai River and in gill net catches immediately after impoundment, have declined since 1982. Jenkins and Morais (1971) found sport fish harvest to be negatively correlated with reservoir age in over 100 North American reservoirs studied. They also found reservoir age to have no affect on total fish standing stock due to increases in clupeid abundance. Total standing stock in Libby Reservoir as indicated by fall floating gill net captures is increasing, and is due to increases in peamouth chubs as well as kokanee, both of which utilize limnetic production. The numerical dominance of these pelagic species became apparent in 1982, 10 years after impoundment. The upward trend in abundance of peamouths, kokanee and yellow perch will probably be controlled by competition for the plankton resource.

#### Limnetic Zone

Species composition of vertical gill net catches in the Tenmile and Rexford areas were more similar to each other than they were to catches from the Canadian portion of the reservoir (Table 19 and Appendix H, Tables H1 - H6). At the north end of the reservoir, peamouths comprised an average of 68 percent of the catch from 1984 to 1987, while kokanee comprised only 13 percent of the catch. In the Tenmile and Rexford areas, peamouth comprised an average of 10 percent and 27 percent, respectively, from 1983 to 1987, while kokanee comprised 82 percent and 60 percent of the catch, respectively.

In 1983, Oncorhynchus trout and bull trout comprised up to 25 percent of the catch in the Tenmile and Rexford areas, but diminished in most cases to less than one percent of the catch in all subsequent years. Vertical gillnetting was not done in Canada in 1983. After 1983, Oncorhynchus trout, mountain whitefish, Catostomus spp. and northern squawfish had a greater relative abundance in Canada than either the Tenmile or Rexford areas. The assemblage of fish in the Canadian area more closely resembles that which is present in the Kootenai River.

Table 19. Relative abundance of fish species<sup>a/</sup> captured in vertical gill nets in three sampling areas in Libby Reservoir, 1983 through 1987.

Year	RB	WCT	HB	COMB	DV	KOK	MWF	CRC	NSQ	RSS	CSU	FSU
<b>TENMILE</b>												
1983	7	2	4	13	12	64	1	9	1	0	0	0
1984	1	1	1	3	1	89	<0.1	6	a	<0.1	a	0
1985	<1	1	a	1	<1	89	0	9	a	0	a	0
1986	<1	a	a	1	1	88	<1	9	0	0	a	0
1987	<1	a	1	1	<1	79	<1	19	a	0	a	0
<b>REXFORD</b>												
1983	4	4	0	8	11	39	0	22	20	0	0	0
1984	2	1	1	4	1	8	5	1	7	1	a	1
1985	1	a	a	1	a	57	<1	37	1	a	a	0
1986	2	0	1	3	a	47	2	44	2	0	1	0
1987	<1	a	0	1	1	72	a	25	a	a	0	0
<b>CANADA</b>												
1984	2	0	2	4	0	14	3	44	14	0	17	3
1985	<1	a	0	1	a	24	0	67	6	1	0	0
1986	1	2	1	5	1	5	2	80	3	0	4	a
1987	2	1	a	3	0	9	1	82	4	a	a	0

<sup>a/</sup> RB=rainbow trout, WCT=westslope cutthroat trout; HB=rainbow x cutthroat trout hybrid, COMB=combined trout, DV=bull trout, KOK=kokanee salmon, MWF=mountain whitefish, CRC=peamouth chub, NSQ=northern squawfish, RSS=redside shiner, CSU=largescale sucker, FSU=longnose sucker.

## HYDROACOUSTIC ESTIMATE OF KOKANEE

### Methods

Kokanee abundance was estimated each year from 1984-1987 using hydroacoustics. Sampling was conducted during moonless nights in August. Visual isolation during moonless nights results in an even dispersal of kokanee thereby increasing the reliability of the technique (Hanzel 1984).

A Honda Sitex depth recorder (Model HE 356A) with a transducer beam angle of 10 degrees and frequency of 220 mHz was used. Cone width was assumed to be consistent with the 10-degree beam angle. Thirty-eight - covering four discrete reservoir areas were surveyed. After July 1985, distance traveled along each transect was measured by a knotmeter. Transect sampling began approximately one hour after sundown using compass bearings and (after 1985) by steering toward flashers placed at the end of each transect. Reservoir sonar sampling was completed within two to four nights, generally with one area (8-10 transects) completed each night.

All targets within interval were counted. The number of kokanee per transect was calculated using vertical gill net species composition proportions. Numbers of kokanee per 1,000 m<sup>3</sup> were calculated for each depth interval. These estimates were then converted to numbers per area and expanded to total surface area using methods and assumptions explained by Shepard (1985) .

### Results and Discussion

Sonar transect lengths were 73 to 76 km, with the exception of the 1986 estimate where the total measured length of the transects was 90.5 km (Appendix I, Tables I1 - 14). The area exhibiting the most variation in transect lengths and volumes was Tenmile. The cause of the extra length in 1986 could be wind-induced drift as the transects were sampled, or recording error. In any case, numbers in 1986, at Tenmile and for the total, were lowest of any of the years sampled

Since their introduction by Canadian fisheries personnel throughout the 1970's, the kokanee population in Libby Reservoir has experienced cyclic population dynamics. Kokanee in Libby Reservoir spawn as 2<sup>+</sup> year old fish and their pattern of abundance is apparently related to a strong 1979 and/or 1981 year class. The pattern is such that every third kokanee year class is "strong" and is followed by two "weaker" year classes. Although this abundance trend is apparently stabilizing, it still dominates kokanee population dynamics in Libby Reservoir. Because the hydroacoustic gear we have used does not have the capability to differentiate size and therefore age class of kokanee, interpretation of our population estimate necessitates an understanding of the kokanee population pattern. Our population

estimates are presumed to include primarily age 1+ and 2+ fish, although the possibility exists that some age 0+ fish were included in the estimate.

In 1984, we estimated that Libby Reservoir contained the highest total numbers of kokanee, 2.5 million fish, primarily composed of a very strong 1983 year class (Table 20). The 1985 estimate was smaller by approximately 500,000 fish. Kokanee numbers in 1986, immediately after the largest (1985) year class spawned, reached the lowest value of any year yet measured. This estimate includes the two 'weakest' year classes for that period, the 1984 and 1985 young-of-the-year.

For comparison, Rieman and Bowler (1980) estimated that kokanee numbers in Pend Oreille Lake, Idaho, ranged from 5 to 12 million fish between 1974 and 1978. Pend Oreille is the largest lake in Idaho with a surface area of 383 km<sup>2</sup>. Interestingly, the kokanee population in Fend Oreille apparently stabilized in 1976 and 1977 before declining in 1978 (Rieman and Bowler 1980).

Estimated densities of kokanee in the Libby Reservoir during August differed by area and year (Table 21). In two of the four years, 1985 and 1986, Peck Gulch had the highest densities, 276.5 and 443.8 fish/ha, respectively. For all four years, the Canada area had the lowest densities, ranging from 5.4 to 17.3 kokanee per hectare.

## FISH AGE AND GROWTH

### Methods

Fish collected in Libby Reservoir and its tributaries were measured as total length (TL) and weighed to the nearest gram (g). Scales were removed from fish in an area above the lateral line and between the dorsal and anal fins following Lagler (1956). Cellulose acetate impressions of the scales were examined at 48X or 72X magnification using a microfiche reader. Distances were measured in a straight line from the focus to the annuli and mid-anterior margin of the scales using a millimeter ruler.

Age and growth information was analyzed using the FIRE 1 computer program (Hesse 1977) as modified by Montana Department of Fish Wildlife and Parks personnel. Age was assigned based on interpretation of annulus formation on scales (Jearld 1983). Body length-scale radius relationships were described using log-log plots and the Monastorsky technique.

Otoliths from a limited number of trout, burbot and salmon were analyzed by Dr. Ed Brothers (EFS consultants, Ithaca, New York) to validate aging by scales and to provide additional information on seasonal and differential growth of fish in the reservoir. Method of analysis was similar to that reported by Brothers et al. (1976) and is described in detail by May et al. (1988).

Table 20. Expanded estimates of kokanee numbers in Libby Reservoir in August, from 1984 to 1987, as determined by hydroacoustic sampling.

Geographic area	Total surface area ha.	acres	Area sampled ha.	acres	Estimated number	95% confidence interval
1984						
Termile	4680.3	11564.9	11.4	28.2	1212184	+ 57819
Peck Gulch	1911.7	4723.7	7.6	18.8	251512	+ 20718
Rexford	4375.1	10810.7	11.4	28.1	1037717	+ 94154
Canada	4867.8	12028.3	9.5	23.4	26116	+ 4738
			-	-		
Total	15834.9	39127.5	39.8	98.4	2527530	+ 177429
1985						
Termile	4620.3	11416.6	10.2	25.3	463856	+ 59942
Peck Gulch	1887.2	4663.1	6.9	17.1	521849	+ 51393
Rexford	4315.1	10662.4	11.8	29.1	1015217	+ 142290
Canada	4317.1	10667.5	9.3	23.1	46990	+ 17275
			-	-		
Total	15139.6	37409.5	38.3	94.6	2047911	+ 271100
1986						
Termile	4687.2	11582.0	13.5	33.4	196870	+ 26778
Peck Gulch	1914.5	4730.7	9.5	23.5	849576	+ 80459
Rexford	4392.5	10853.6	14.6	36.1	537992	+ 48760
Canada	5026.0	12419.2	9.9	24.6	86950	+ 27065
			-	-		
Total	16020.2	39585.4	47.5	117.5	1671389	+ 183062
1987						
Termile	4673.4	11547.8	11.5	28.5	596503	+ 74038
Peck Gulch	1908.9	4716.7	7.2	17.8	289342	+ 61419
Rexford	4375.1	10810.7	11.4	28.2	958010	+ 179589
Canada	4787.3	11829.2	9.0	22.2	31658	+ 7267
			-	-		
Total	15744.6	38904.4	39.2	96.8	1875513	+ 322314

Table 21. Mean kokanee density in four areas of Libby Reservoir during August 1984 to 1987, as determined by hydroacoustic sampling.

Area	Number per Acre	95% Confidence Interval		Number per ha.	Newman-Keuls <sup>a/</sup> Multiple Comparison
<b>1984</b>					
TENMILE	104.8	95.1	- 114.5	259.0	A <sup>b/</sup>
PECK GULCH	53.2	46.3	- 60.2	131.6	B
REXFORD	96.0	79.2	- 112.8	237.2	A
CANADA	2.2	1.4	- 3.0	5.4	C
<b>1985</b>					
TENMILE	40.6	31.0	- 50.3	100.4	A
PECK GULCH	111.9	95.3	- 128.6	276.5	B
REXFORD	95.2	68.9	- 121.5	235.3	B
CANADA	4.4	1.1	- 7.7	10.9	C
<b>1986</b>					
TENMILE	17.0	12.1	- 21.9	42.0	A
PECK GULCH	179.6	149.5	- 209.7	443.8	B
REXFORD	49.6	39.7	- 59.4	122.5	C
CANADA	7.0	2.4	- 11.6	17.3	A
<b>1987</b>					
TENMILE	51.7	39.2	- 64.1	127.6	A
PECK GULCH	61.3	41.3	- 81.4	151.6	A
REXFORD	88.6	56.4	- 120.8	219.0	B
CANADA	2.7	1.4	- 3.9	6.6	C

<sup>a/</sup> ANOVA test indicated significant differences among areas for all years: 1984 (F3, 34=88.13, p<0.0001); 1985 (F3, 34=40.04, p<0.0001); 1986 (F3, 34=114.11, p<0.0001); 1987 (F3, 34=13.57, p<0.0001).

<sup>b/</sup> Number/area values that are significantly different are indicated by different capital letters.

## Results and Discussion

Fish growth is influenced by many factors (Ploskey 1986, Piper et al. 1982). Water temperature and other habitat characteristics (Brett 1971, Everhart and Youngs 1981), food availability and nutrition (Wolfert and Miller 1978, Piper et al. 1982), and competition (Calhoun 1966, Carlander 1969, Christie 1974, Schiavone 1985) have all been documented to affect fish growth. Kokanee exhibit density-dependent growth (Johnson 1965, Foerster 1968) and effects of reservoir operation on area or volume of the reservoir may influence population densities (Jenkins 1970, Aggus 1979). However, any effects of reservoir operation on growth are confounded by influences of temperature, competition, food availability and habitat characteristics.

### Rainbow trout

Age determination and scale measurements were performed on 417 rainbow trout captured in Libby Reservoir. The intercept of the scale radius vs. body length regression line was 16.14 mm with a slope of 0.62 and a correlation coefficient of 0.84.

Analysis of scales showed that there were distinct transition zones of growth where circuli became wider, finer and very uniform. These were believed to be zones formed following emigration from natal streams to the reservoir. Annuli formed during growth in the reservoir were recognized by a periodic pattern in the fall and winter where spacing between circuli became less. Growth after the first year was slower and annual zones were more difficult to interpret. An explanation for this could be slowing of trout growth due to maturation or change in food habits (Mueller and Rockett 1980; Hensler 1987).

Five distinct migration classes (trout that emigrated from natal streams to the reservoir at ages 0+, 1+, 2+, 3+, and 4+) were determined to exist in the samples based on scale aging techniques (Table 22). Migration classes 0, I and II made up the vast majority of the sample (44, 38, and 14 percent, respectively). Migration classes III and IV had small sample sizes (3 and 2, respectively) and were therefore not included in the following discussion.

Migration class was apparently related to size at age. Trout migrating at younger ages had a growth advantage over older migrants, due to the difference between growth in the reservoir versus the stream. Rainbow trout migrating as fry were the largest-sized class as one-year-olds, followed in size by migration classes I and II. As two-year-olds, migration class I trout were similar in size to the trout migrating as fry. At age three, earlier migrants averaged 55 mm longer than class II; the difference was 34 mm at age four, and by age five all migration classes were similar in length.

Table 22. The calculated mean total lengths (mm) at annuli for rainbow trout trout in Libby Reservoir, 1984 through 1987. Measurements based on scale analysis.

Age	(N)	Mean length at capture (mm)	Annulus					
			1	2	3	4	5	6
Migration Class 0								
1	6	293	123	-	-	-	-	
2	20	318	122	299				
3	20	369	128	308	359	-		
4	11	400	134	309	378	399	-	
5	1	446	140	249	352	420	446	
Grand Mean			127	303	365	401	446	
Growth increment				176	62	36	45	
Migration Class I								
1	41	260	98	-		-	-	
2	61	347	108	307	-	-	-	
3	59	375	107	294	357	-	-	
4	17	416	110	300	379	411	-	
5	5	408	112	279	353	390	408	
Grand Mean			105	300	361	406	408	
Growth increment				195	61	45	2	
Migration Class II								
2	40	281	93	155	-			
3	48	327	95	161	302			
4	49	373	99	162	310	366	-	
5	20	403	100	167	319	377	402	
6	3	408	97	158	304	355	394	408
Grand Mean			96	161	308	369	401	408
Growth increment				65	147	61	32	7
Migration Classes Combined								
1	47	265	101	-	-	-	-	
2	121	320	105	255	-	-	-	
3	133	353	105	242	331	-	-	
4	83	386	104	209	326	378	-	
5	30	396	103	186	309	370	395	
6	3	408	97	158	304	355	394	408
Grand Mean			104	234	326	375	395	408
Growth increment				130	92	49	20	13

Mean lengths at annuli for stream residence of trout migrating as one- and two-year-olds were greater than those found by Huston et al. (1984) between 1972 and 1982. Lengths at annuli during reservoir life were slightly lower for trout in this study until age four, at which point they were similar. It is likely that this is related to the drop in abundance of redbreasted sunfish, at one time an important food item for rainbow trout over 330 mm (Huston et al. 1984, McMullin 1979). Between 1983 and 1987, rainbow trout fed largely on zooplankton and insects and very little on fish (see section on Fish Food Habits). Evidence suggesting that this change in food habits may have altered growth rates is given by Helsler (1987) who studied rainbow trout in Montana lakes and found that fish that relied heavily on daphnids grew more slowly after 350 mm TL than those that switched to larger food items.

Several authors have noted the possibility of scale aging being inaccurate (Beamish and McFarlane 1983, Boyce 1985, Hubert et al. 1987). Beamish and McFarlane stated that validation is absolutely necessary for accurate age determination and reported that if known age fish were not available, validation by different techniques should be considered. Hubert et al. (1987) found that aging with scales and otoliths in combination yielded accurate results.

For this study, findings based on otolith analysis were similar to those from scales. Otolith analysis determined that migration class I and II fish were 108 mm and 147 mm TL, respectively, at annuli formed prior to emigration to the reservoir in 1985 (Table 23). These back-calculated lengths were about 10 percent smaller than those derived from scale analysis, where migration class I and II fish were 120 mm and 166 mm TL, respectively, at annuli formed prior to emigration in 1985 (subset of data in Table 22).

Brothers (1987) analyzed rainbow trout otoliths from Libby Reservoir and found there to be a transition zone of growth between stream and reservoir. He found that this transition may be abrupt, with the increments becoming wider and more uniform, or else the transition is more gradual with an intermediate area of poorly defined increments before reservoir growth. His results indicate that fish enter the reservoir in the last week of May through the first two weeks of June.

Monthly increments of growth derived from otoliths indicated that migration class I fish grew at a faster rate than migration class II fish during their first year in the reservoir, but that both migration classes grew fastest from April to June (Table 23). Migration class I fish grew 51 mm/month between April and June and slowed to 17 mm in October; migration class II fish grew 36 mm/month from April to June and slowed to 15 mm in October.

Table 23. Mean back-calculated lengths and monthly growth rates of rainbow trout after entry into Libby Reservoir, 1985. Measurements based on otolith analysis.

Age at entry	Lengths (mm) at stream annulus (N)	Lengths (mm) at dates (growth/mo.)					
		Apr-Jun	Jul	Aug	Sep	Oct	
1	24	108	159 (51)	189 (30)	218 (29)	243 (24)	259 (17)
2	18	147	184 (36)	212 (27)	239 (25)	262 (22)	278 (15)

## Westslope Cutthroat Trout

Age and growth determinations were made on 354 westslope cutthroat trout collected from Libby Reservoir from 1984 through 1987. The intercept of the scale radius-body length regression line was 15.08 mm with a slope of 0.66 and a correlation coefficient of 0.90.

Based on scale analysis, the sample of captured cutthroat trout consisted of migration classes 0, I, II, and III, with migration classes II and III making up the majority of the sample (67 percent, and 22 percent, respectively) (Table 24). Fish in all migration classes nearly doubled in length from time of emigration to the reservoir to the first annulus formation in the reservoir. Lengths at first reservoir annulus were similar for migration classes I, II, and III (302 mm, 303 mm, and 309 mm, respectively). Migration class 0 put on most growth during the second growing season in the reservoir. Migration classes 0 and I maintained a length advantage over other classes until age five at which point all classes were similar in length,

Lengths at first reservoir annulus averaged about 75 mm TL greater for class I migrants than those reported by Huston et. al. (1984) between 1972 and 1982. Cutthroat trout in this study maintained that advantage through age three. Similarly, lengths for migration classes II and III were greater in this study than those found by Huston et al., but the size differences were much less (10 mm and 7 mm, respectively).

A possible explanation for cutthroat trout being more similar in lengths at age than was seen in rainbowtrout maybe found in their respective food habits. Cutthroat trout tend to feed more heavily on daphnids and aquatic and terrestrial insects (McMullin 1979). Therefore, a decrease in the redbside shiner population would not adversely affect cutthroat trout as it would rainbows.

Lengths of migration classes II and III cutthroat trout also were higher than those reported for Hungry Horse Reservoir (May et. al. 1988) and for Flathead Lake (Leathe and Graham 1982). This may reflect higher productivity in the Kootenai River system than in the Flathead system.

## Rainbow X Cutthroat Hybrids

Age determination and scale measurements were performed on 321 hybrid trout. The intercept for body length-scale radius regression line was 16.14 with a slope of 0.63 and a correlation coefficient of 0.84. In addition, otoliths from 57 hybrids were used to assess monthly growth.

Analysis of scales showed the sample to consist of migration classes I, II, III, and IV. Migration class II made up the majority of hybrids captured (59 percent) while the others were similar and ranged from 12 to 15 percent (Table 25). Back-

Table 24. The calculated mean total lengths (mm) at annuli for westslope cutthroat trout in Libby Reservoir, 1984 through 1987. Measurements based on scale analysis.

Age	(N)	Mean length at capture (mm)	Annulus					
			1	2	3	4	5	6
Migration Class 0								
1	3	255	126	-				
2	7	303	129	285	-			
3	9	367	136	285	347	-		
4	1	385	153	255	340	369	-	-
Grand Mean			133	283	346	369	-	-
Growth increment			150	63	23			
Migration Class I								
1	5	209	88	-	-	-	-	-
2	3	302	118	289	-	-	-	-
3	2	413	102	338	398	-		
4	2	399	136	286	355	399	-	-
Grand Mean			106	302	376	399	-	-
Growth increment			196	74	23			
Migration Class II								
2	79	241	83	140	-			
3	61	320	95	163	298	-	-	-
4	37	367	97	164	309	360	-	-
5	6	392	93	175	312	361	392	-
6	1	408	81	152	319	375	397	408
Grand Mean			90	154	303	361	392	408
Growth increment			64	149	58	31	16	
Migration Class III								
3	31	229	80	125	165	-		
4	18	313	81	134	187	297	-	-
5	7	383	89	147	205	334	376	-
6	1	405	93	145	198	325	379	405
Grand Mean			82	132	178	309	377	405
Growth increment			50	46	131	68	28	
Migration Class Combined								
1	26	267	145	-	-	-	-	-
2	118	268	106	193	-	-	-	-
3	125	310	105	193	279	-	-	-
4	68	351	101	175	278	342	-	-
5	13	387	91	160	254	347	383	-
6	4	406	90	147	228	337	384	406
Grand Mean			107	187	276	342	383	406
Growth increment			80	89	66	41	23	

Table 25. The calculated mean total lengths (mm) at annuli for rainbow X cutthroat trout in Libby Reservoir, 1984 through 1987. Measurements based on scale analysis.

Mean length at capture			Annulus					
Age (N)		(mm)	1	2	3	4	5	6
Migration Class 0								
1	8	281	142	-	-	-	-	
2	18	351	143	319			-	
3	4	377	136	295	358	-	-	
4	6	430	152	330	392	427	-	
5	1	421	126	271	361	403	421	
Grand Mean			143	316	377	424	421	
Growth increment			189	58	35			
Migration Class I								
1	10	221	99	-	-	-		
2	12	359	103	312	-	-		
3	18	365	108	290	353	-	-	
4	5	387	104	262	345	380	-	
5	1	440	96	270	351	415	440	
Grand Mean			104	293	351	386	440	
Growth increment			189	58	35		54	
Migration Class II								
2	62	230	89	142	-		-	
3	71	332	99	162	301	-	-	
4	40	374	101	167	303	359		
5	17	417	98	162	320	371	411	
Grand Mean			96	156	304	363	411	
Growth increment			60	148	59		48	
Migration Class III								
3	23	214	87	129	163	-	-	
4	16	335	89	140	191	316	-	
5	6	337	91	143	188	286	-	
6	2	412	93	180	240	331	370	412
Grand Mean			89	137	179	309	340	412
Growth increment			48	42	130		31	72
Migration Classes combined								
1	18	248	118	-	-	-	-	-
2	92	271	101	199	-	-	-	-
3	116	315	99	180	284	-	-	-
4	68	369	103	182	286	355	-	-
5	25	399	97	166	291	354	393	-
6	2	412	93	180	240	331	370	412
Grand Mean			101	185	285	354	392	412
Growth increment			84	100	69		38	20

calculated lengths at annuli were very similar to both rainbow trout and cutthroat trout. All migration classes were approximately 300 mm TL after the first growing season in the reservoir. Migration classes 0 and I maintained a growth advantage over other classes that was achieved the first year in the reservoir and lasted through year five.

Growth increments were similar to those of cutthroat trout and rainbow trout, suggesting that in Libby reservoir, life histories of the different trout types are similar. Greatest growth of hybrid trout was achieved in the first year of reservoir life. Growth increments decreased from 189 mm TL to 130 mm TL as age at migration increased. Otoliths were used to determine monthly growth rates of age 2+ hybrid trout during their first summer in the reservoir in 1986. Rack calculation of otoliths revealed that fish averaged 173 mm TL upon entering the reservoir in mid June, and grew by increments of 32 mm, 30 mm and 27 mm during subsequent 30-day intervals.

### Kokanee

Otolith measurements from a sample of 100 kokanee captured between 1984 and 1987 were analyzed to determine monthly and annual lengths and growth rates. Because the majority of kokanee in Libby Reservoir spawn at age 2+ and sample sizes of 3+ and 4+ kokanee were low (two and one, respectively), discussion will be limited to age classes 1 and 2.

Age 2+ kokanee showed the greatest second year growth in 1986 (141 mm), followed by 1983 (125 mm) and 1985 (103 mm) (Table 26). Age 1+ kokanee showed similar differences in annual lengths among years, with greatest growth occurring in 1983 and 1986, and least growth in 1985 (Table 27). It has been well documented that salmon populations exhibit density-dependent growth (Johnson 1965, Foerster 1968, Goodlad et al. 1974). The year when both age 1+ and 2+ kokanee growth declined in Libby Reservoir (1985) was a year of relatively high density (Table 20); conversely, growth was relatively high in 1986 when total numbers were lower. It is possible that high numbers of both age classes exert a density-dependent pressure and thereby decrease growth.

Otoliths were used to determine monthly growth rates for age 2+ kokanee (Table 28). For the period June through October, growth increments were highest in the June-July interval and lowest in the August-September or September-October interval. The high rates in June through July correspond with blooms of Daphnia in the reservoir and their association with water temperatures preferred by kokanee. Two-year-old kokanee captured in 1986 showed greatest growth in the August-September interval.

Table 26. The calculated mean total lengths (mm) at otolith annuli for kokanee salmon in Libby Reservoir, 1984 through 1987.

Age	(N)	Mean length at capture (mm)	Annulus	
			1	2
1984				
1	36	302	173	
2	4	413	183	301
Grand Mean			176	301
Growth Increment				125
1986				
1	8	308	155	
2	3	413	189	292
Grand Mean			165	292
Growth Increment				103
1987				
1	14	173	170	
2	31	316	140	293
Grand Mean			147	293
Growth Increment				141

Table 27. Back-calculated and back-dated lengths at first otolith annulus for kokanee salmon in Libby Reservoir, 1983 through 1987.

Year of growth	Year of annulus	Length (mm)	Number of fish
1983	1984	178	35
1984	1985	164	3
1985	1986	142	38
1986	1987	170	14

Table 28. Back-calculated lengths and mean monthly growth (mm) for age 2+ kokanee salmon in Libby Reservoir, 1984 through 1987. Measurements based on otolith analysis. Sample size is in parenthesis.

Year	Time of year						
	Previous Winter	Spring	June	July	Aug.	Sept.	Oct.
1984	178(31)	-	200(3)	234(11)	258(24)	280(31)	301(31)
increment			34	24	22	21	
1986	142(20)	184(20)	-	222(12)	247(20)	279(20)	296(13)
increment	42			25	32	17	
1987	186(6)	228(6)	244(3)	270(6)	293(6)	311(6)	
increment	42	16	26	23	18		

## Bull Trout

Age determinations and scale measurements were made on 78 bull trout from 1985 through 1987. The intercept of the body length-scale radius regression line was 12.33 mm with a slope of 0.802 and a correlation coefficient of 0.80.

Three-, four- and five-year-olds comprised the majority of the catch of bull trout during the study period (21 percent, 38 percent, and 28 percent, respectively) (Table 29). Captured bull trout comprised three migration classes. The highest percentage of the catch was from migration classes II and III (59 percent and 38 percent, respectively). Composition of migration classes was similar to that found in Libby Reservoir from 1972 through 1982 by Huston et al. (1984).

Growth among all migration classes of bull trout was similar for the first year in the reservoir (126 mm, 110 mm, and 107 mm for migration classes II, III, and IV, respectively). First year growth increments in this study were greater than those reported by Huston et al. (1984) for Libby Reservoir from 1972 through 1982, by Leathe and Graham (1982) for Flathead Lake, or May et al. (1988) for Hungry Horse Reservoir. In addition, bull trout in Libby Reservoir exhibited greater growth up to age four than these other Montana studies, at which point growth was comparable. This suggests that there may be more readily available food organisms for smaller bull trout in Libby Reservoir but that those items are not enough to maintain the growth advantage for larger fish. Carlander (1969) noted that the intermediate-size bull trout (130 mm to 380 mm) fed most heavily on a spawning population of salmon and that kokanee were the principle food of bull trout in some Idaholakes.

Growth of migration class II bull trout to first annulus in the reservoir was greater than growth of migration classes III and IV, although migration class IV had a sample size of only two. This growth advantage was also carried up to the sixth year of life. Growth increments within the reservoir, although, were greater for migration class III than for migration class II and it appears likely that if continued for several more years, the length advantage gained by migration class II would diminish.

This pattern is considerably different than bull trout growth reported for Hungry Horse Reservoir (May et al. 1988). Growth increments of migration classes II and III in Hungry Horse Reservoir remained similar and stable for the first five years of life including the first year of reservoir life. Growth increments for migration classes II and III increased by only 18 mm and 11 mm, respectively, between last year of stream growth and first year of reservoir growth. Greatest growth was at age five for migration class II fish and age six for migration class III fish. Once again it appears as though upon entering the reservoir, some feeding advantage was gained in Libby Reservoir relative to the other areas noted above.

Table 29. The calculated mean total lengths (mm) at annuli for bull trout in Libby Reservoir, 1984 through 1987. Measurements based on scale analysis.

Age	(N)	Mean length at capture (mm)	Annulus						
			1	2	3	4	5	6	7
Migration Class II									
2	4	275	111	214	-	-	-	-	
3	13	359	104	171	313	-	-	-	
4	21	420	107	181	310	388	-	-	
5	7	484	110	181	292	384	459	-	
6	1	535	129	220	296	373	446	517	
Grand Mean			107	182	308	387	457	517	
Growth increment			75	126	79	70	63		
Migration Class III									
3	3	263	81	149	214	-	-	-	
4	9	396	99	164	224	328	-	-	
5	15	462	102	161	223	335	418	-	
6	3	468	88	150	211	309	391	457	
7	1	765	126	213	286	413	520	606	699
Grand Mean			99	161	223	333	419	494	699
Growth increment			62	62	110	86	75		
Migration Class IV									
5	1	373	105	145	192	248	373	-	
6	1	411	97	137	189	248	338	386	
Grand Mean			101	141	190	248	355	386	
Growth increment			40	49	58	107	31		
Migration Classes combined									
2	4	275	111	214	-	-	-	-	
3	16	380	102	170	270	-	-	-	
4	30	410	104	172	265	350	-	-	
5	23'	440	106	162	240	334	416	-	
6	3	454	110	190	257	344	391	453	
7	1	765	126	213	189	413	520	606	699
Grand Mean			110	187	244	360	442	530	699
Growth increment			77	57	116	82	88	169	

## Mountain Whitefish

Age determination and scale measurements were performed on 168 mountain whitefish. The intercept of the body length-scale radius regression line was 12.25 mm with a slope of 0.709 and a correlation coefficient of 0.88.

Huston et al. (1984) reported that mountain whitefish fry do not rear in tributaries but moved directly to Libby Reservoir after hatching. This is consistent with the scale analysis, which showed greatest growth occurring in the first year of life, presumably corresponding to initial growth in the reservoir. Lengths at annuli continually decreased after that time (Table 30).

These results are comparable to those reported by Huston et al. (1984) except that length at the first annulus was higher in this study. In addition, lengths at annuli for mountain whitefish in Libby Reservoir were greater than those of populations found in other Montana lakes (Carlander 1969).

## Burbot

Otoliths from 56 burbot collected in Libby Reservoir were utilized for age and growth analysis. A summary of the aging data is shown in Figure 22 and Table 31. No back-calculation of ages was attempted due to the presence of "false" annuli and difficulty of measurement. Brothers (1987) noted that although the annular marks were not rigorously validated, microstructural examination revealed the presence of seasonal growth patterns consistent with the age interpretation represented in Figure 22 and Table 31.

Sampled burbot ranged between 3 and 11 years old, with the mode at age 5. Corresponding lengths ranged between 269 mm and 1,003 mm TL. These lengths at age are smaller than those reported by Huston et al. (1984) for fish captured between 1975 and 1980. There was high variability in lengths at age because times of capture included all seasons.

## Northern Squawfish

Scales from 17 northern squawfish were used for age and growth analysis. The scale radius-body length regression line intercept was 5.45 mm with a slope of 0.872 and correlation coefficient of 0.96. Growth increments gradually decreased after a high in the first year in the reservoir (Table 32). Year six was an exception in that it was about double the adjacent years, and was therefore probably an artifact of the low sample size. Annular lengths were all considerably greater than those reported for other Montana lakes and reservoirs (Carlander 1969). Because of low sample size these data should be interpreted with caution.

Table 30. The calculated mean total lengths (mm) at annuli for mountain whitefish in Libby Reservoir, 1984 through 1987. Measurements based on scale analysis.

Age	(N)	Mean length at capture (mm)	Annulus							
			1	2	3	4	5	6	7	8
1	4	190	108						-	-
2	46	247	132	224	-				-	-
3	44	278	131	221	267				-	-
4	38	313	133	230	280	306			-	-
5	24	344	139	228	285	318	339	-	-	-
6	11	360	145	236	285	317	341	357	-	-
7	0	0							-	-
8	1	365	129	260	290	306	325	342	356	365
Grand Mean			133	226	277	311	339	356		
Growth increment				93	51	34	28	17		

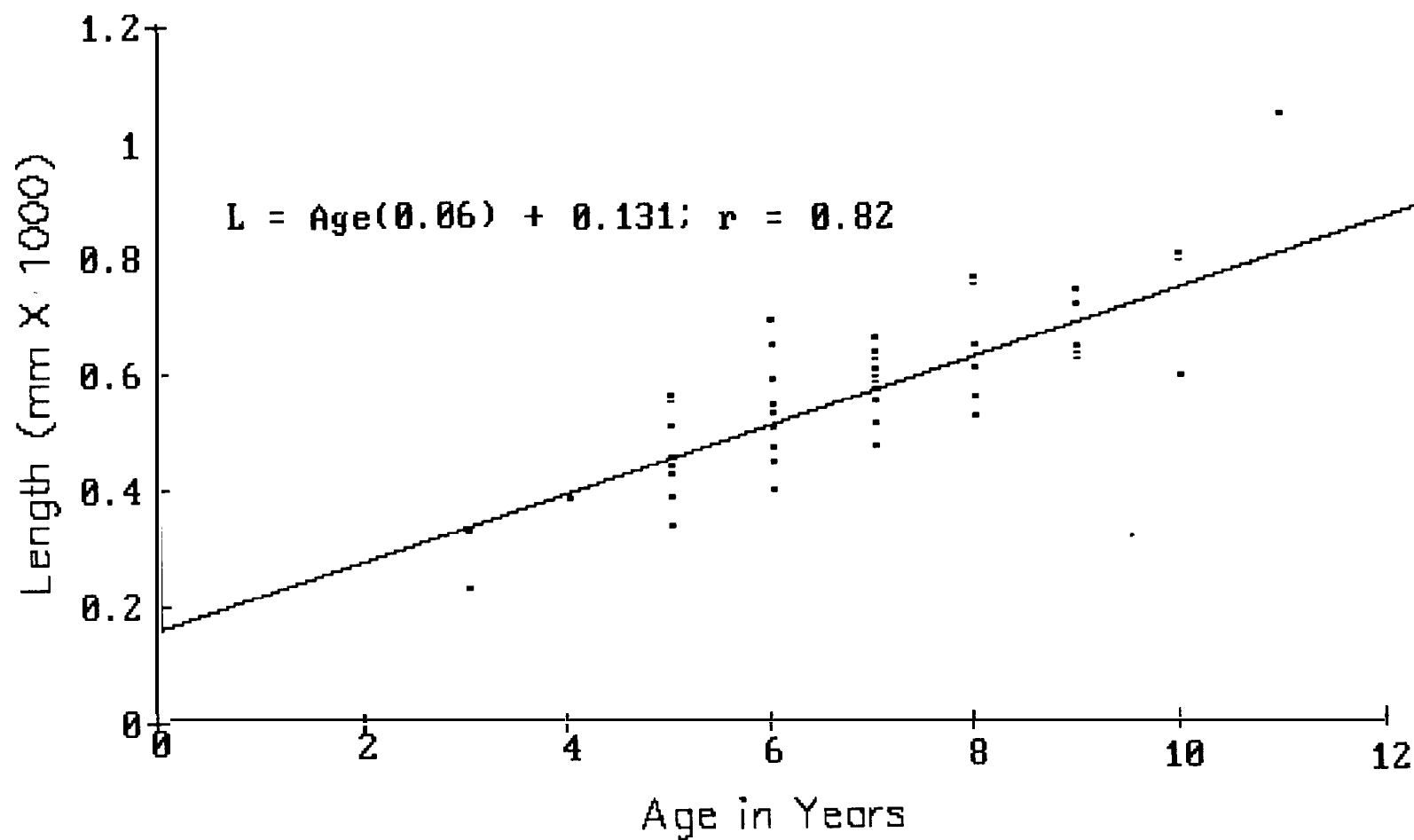


Figure 22. Estimated length of burbot at specified ages in Libby Reservoir, 1984 through 1987.

Table 31. Mean length at capture of 1984-1987 age classes of burbot collected from Libby Reservoir, 1984 through 1987. Assignment of age classes based on otolith analysis.

Age Class	Length at capture (mm)	Sample size
3	269	2
4	373	2
5	449	13
6	513	12
7	553	11
8	623	6
9	650	5
10	701	3
11	1,003	1

Table 32. The calculated mean total lengths (mm) at annuli for northern squawfish in Libby Reservoir, 1984 through 1987. Measurements based on scale analysis.

Age	(N)	Mean length at capture (mm)	Annulus										
			1	2	3	4	5	6	7	8	9	10	11
2	2	200	78	160	-	-	-	-	-	-	-	-	-
3	1	293	98	192	267	-	-	-	-	-	-	-	-
4	3	304	104	171	238	280	-	-	-	-	-	-	-
5	4	332	91	168	242	287	319	-	-	-	-	-	-
6	4	348	75	150	219	269	311	337	-	-	-	-	-
7	0	-	-	-	-	-	-	-	-	-	-	-	-
8	1	485	110	162	224	296	344	376	410	454	-	-	-
9	0	-	-	-	-	-	-	-	-	-	-	-	-
10	1	500	83	133	198	248	288	337	377	409	442	471	-
11	1	545	92	172	245	315	363	410	448	485	500	518	531
Grand Mean			92	166	238	283	323	358	426	455	471	494	531
Growth increment			74	72	45	40	35	68	29	16	23	37	-

## Peamouth chub

A small sample of scales (19) from peamouth chubs captured in Libby Reservoir was analyzed for age and growth (Table 33). The intercept of the scale radius-body length regression line was 9.92 mm with a slope of 0.69 and a correlation coefficient of 0.89.

Growth was greatest in the first three years of life, gradually decreasing with age. The growth increment between ages six and seven maybe an artifact of low sample size. Carlander (1969) reported annular lengths for peamouth chubs from other Montana lakes including Flathead lake, all of which were lower than the Libby Reservoir sample. Although these data should be interpreted with caution, the large size exhibited by peamouth chubs caught in gill nets in Libby Reservoir leads us to believe that the actual growth of this species is outstanding and likely mirrors their growth as determined by scale analysis.

## FISH FOOD HABITS

### Methods

Stomachs of various fish species captured in gill nets from 1983 through 1987 were collected and emptied into labeled plastic vials with a formalin preservative (prior to fall 1986) or with a 95 percent ethanol solution (after fall 1986). Stomach contents were sorted into taxonomic groups, counted and weighed. Subsampling was used when analyzing zooplankton and other abundant, small food items. Wet weights of all food categories except zooplankton were measured to the nearest 0.001 g after removing excess water by blotting.

The majority of zooplankton ingested by fish were fragmented, and identifiable body parts were used to estimate the number of each genus within each stomach. In the earliest samples (summer 1983), lengths of Bosmina spp., Diaptomus spp., Epishura spp. and Cyclops spp. were estimated as 0.3, 0.7, 1.2 and 0.5 mm, respectively, based on average lengths found in zooplankton collections at the time fish stomachs were sampled. Beginning in fall 1983, lengths were determined directly from stomach samples. Dry weights of these zooplankton were estimated using length-weight regressions presented by Bottrell et al. 1976. All dry weights were converted into wet weights using a multiplication factor of 10. This multiplication factor is applicable for wet weights between 10 and 300 mg (Bottrell et al. 1976), the range most frequently found in Libby Reservoir. We assumed an average length of 6 mm for all Leptodora spp. and used this length to enter length-weight tables developed by Cummins et al. (1969) to estimate the wet weights of Leptodora spp. For stomachs collected in summer 1983, body lengths of Daphnia spp. were estimated using measurements of the post-abdominal claw following methods presented by Leathe and Graham (1982). Beginning in fall 1983, Daphnia spp. body lengths were measured directly from stomach samples.

Table 33. The calculated mean total lengths (mm) at annuli for peamouth chubs in Libby Reservoir, 1984 through 1987. Measurements based on scale analysis.

Age	(N)	Mean length at capture (mm)	Annulus						
			1	2	3	4	5	6	7
3	1	213	72	125	178	-	-	-	-
4	6	230	70	125	171	214	-	-	-
5	8	258	75	133	186	224	249	-	-
6	3	273	75	139	192	228	251	269	-
7	1	332	70	117	199	240	284	316	325
Grand Mean			73	130	182	222	253	280	325
Growth increment				57	52	40	31	27	45

Species and size selection of Daphnia were expressed using Ivlevs (1961) electivity index as presented by Leathe and Graham (1981). The index ranges from -1 (avoidance of a food item) to +1 (positive selection of a food item). A value of zero represents a food item that has the same composition in the environment and the fish.

An index of relative importance (IRI) was calculated to estimate the importance of particular food items in the diet (George and Hadley 1979). The IRI is the arithmetic mean of the number, frequency of occurrence, and weight of a food item in the diet, expressed as a percentage. IRI values range from zero to 100, with a value of 100 indicating exclusive use of a food item. Frequency of occurrence and weight data were used to calculate IRI's for insect parts, algae, and debris.

The Shoener overlap index (Shoener 1970) was used to determine potential dietary overlap between species. The Shoener index gives values from zero (no overlap) to one (complete overlap).

## Results and Discussion

A total of 2,494 fish stomachs from Libby Reservoir were collected and analyzed for food habits from 1983 through 1987 (Table 34). Empty stomachs (475) were not used in the analyses. In addition, stomachs from all geographic areas were used to insure that a complete sample was taken from the entire reservoir.

### Kokanee

Stomachs from 386 kokanee captured between 1983 through 1987 were used in food habits analysis (Table 35). In all years, zooplankton were the most important food items for kokanee salmon. Index of Relative Importance (IRI) values ranged from 92 to 98 between 1983 and 1987.

Daphnia were the most important food for kokanee with respect to zooplankton utilization. Importance values ranged from a low of 59 in 1985 to a high of 96 in 1987. The copepods Diaptomus were next in importance and never comprised more than 29 percent of the diet of kokanee. The other food items were primarily dipteran larvae and pupae. The food habits of kokanee in Libby Reservoir are similar to those in other lakes (Finnel and Reed 1969, Leathe and Graham 1981, Schneidervin and Hubert 1987).

Monthly IRI's again showed the importance of zooplankton in the diet of kokanee (Table 36). Daphnia species were the most important food items for all months except February when Diaptomus became the most important. Diaptomus was also important as a secondary food source between December and April. Epischura, a large copepod, was important sporadically throughout the summer and fall months.

Table 34. Number of stomachs collected for food habits analyses from three areas of Libby Reservoir from 1983 through 1987<sup>a/</sup>. Lengths indicated for trout (<330, >330) are in millimeters

Area	Species															
	RB		WCT		HB		DV	KCK	MWF	LING	RSS	NSQ	CSU	RSU	YP	CFC
	<330	>330	<330	>330	<330	>330										
<u>Termile</u>																
Summer/1983	1	16		2		3	-	-	5		4	4	6	3		4
Fall/1983	8	10	4	6	2	11	1	2	11	2	15		-	-		5
Winter/1984	7	10	4	4	4	6	4	8	2	4		4	5	2		5
Spring/1984	11	10	5	11	10	4	5	15	1		6	5	5	5		5
Fall/1984	14	12	6	7	6	8	15	9	4	4		6	5	4	2	5
Spring/1985	5	12	3	10	2	6	7	10	8	1		5	5	-	2	5
Summer/1985	5	8	6		7	5	2	22	9	2		5	4	3	2	5
Fall/1985	15	12	9	6	8	1	2		5	11	3	5	-			5
Spring/1986	-					-	8	21	-	1		2	-		-	-
Fall/1986	3	10	6	9	12	10	-	19	14		1	24	-		1	19
Winter/1986	-					-	-	2	-		-	-	-		-	-
Total	64	100	43	55	5	44	44	113	65	17	12	65	30	17	7	58
<u>Rexford</u>																
Summer/1983	4	40	11	10	5	4	-	-	2		5	5	4	2	-	5
Fall/1983	8	10	2	5	3	9		3	1	5	2	4	-	-	-	5
Winter/1984	9	10	13	7	11	10	3	25	10	1		5	5	2	-	5
Spring/1984	5	11	1	6	2	11	13	10	8	4	6	5	5	6	5	5
Fall/1984	11	11	7	10	11	3	25	11	6			5	5	0	1	5
Winter/1985	12	9	12	9	11	9	10	9	11	4		5	2	4	-	5
Spring/1985	10	4	4	1	7		3	12	7	5	-	-	-		2	-
Summer/1985	9	8	10	1	5	7	-	3	12		5	5	-		9	5
Fall/1985	12	11	12	8	12	5	10	10	9			5	-		4	3
Spring/1986	-					-	27	-	12	18	-	-	-		4	5
Fall/1986	9		2	2		3	4	19	17		6	15	1		2	22
Spring/1987	15	16	8	3	10	4	15	29	19	12	-	20	19	17	23	21
Total	104	130	82	62	77	65	113	129	139	44	24	104	41	31	50	86
<u>Canada</u>																
Summer/1983	-	6	2			-	-	1	4		4	5	5	1	-	5
Fall/1983	8	9	10	6	13	8	3	2	10		16		-		-	6
Winter/1984	Frozen															
Spring/1984	Dewatered															
Fall/1984	12	10	9	4	10	4	3	11	14	1		5	5	1	-	6
Summer/1985	8	13	8		3	7	1	17	13	1	15		-		-	5
Fall/1985	12	6	10	2	2	2	-	-	1		-	-	-		-	-
Fall/1986	4	10	11	5	3	9	1	23	1		1	12	11		-	19
Total	44	44	50	17	31	30	9	54	43	2	7	34	21	2	0	41

<sup>a/</sup> RB-rainbow trout, WCT-westslope cutthroat trout; HB-rainbow x cutthroat trout hybrid, SAHO-combined trout, DV-bull trout, KCK-kenai salmon, MWF-mountain whitefish, CFC-peamouth chub, NSQ-northern squawfish, RSS-redside shiner, CSU-largescale sucker, RSU-longnose sucker.

Table 35. Indices of Relative Importance for food items in the stomachs of kokanee salmon in Libby Reservoir, 1983 through 1987.

Sample Size:	N=26 1983	N=118 1984	N=129 1985	N=84 1986	N=29 1987
ZOOPLANKTON					
<u>Daphnia</u>	83	74	59	96	72
<u>Diaptomus</u>	10	19	29	2	20
<u>Epischura</u>	3	5	6		
Other plankton		0			
TERRESTRIAL INSECTS					
Hymenoptera	-	0	0		
Coleoptera	1	1			
Hemiptera	-				
Other insects	-	0	1		
AQUATIC INSECTS					
Diptera larvae			0	1	
Diptera pupae	1	0	3	0	8
Insect parts	1	1	1		
Debris		0			

Table 36. Monthly Indices of Relative Importance for food items in the stomachs of kokanee salmon in Libby Reservoir, 1983 through 1987.

Sample size:	N=24	N=34	N=30	N=30	N=44	N=13	N=17	N=53	N=65	N=25	N=34	N=17
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
ZOOPLANKTON												
<u>Daphnia</u>	82	49	54	76	64	81	97	88	97	92	71	83
<u>Diaptomus</u>	17	51	45	20	9					2	2	15
<u>Epischura</u>	1					12	-	12	1	2	23	
Other plankton							3					
TERRESTRIAL INSECTS												
Hymenoptera	-					3	-			4		
Coleoptera			1			3						2
Hemiptera	-											
Other insects	-				2						1	
AQUATIC INSECTS												
Diptera larvae	-			3	1						-	
Diptera pupae	-				17				1	-	-	
Insect parts	-				7				1	-	2	
Debris	-										2	

Daphnia IRI values were extremely high relative to their relative abundance in Libby Reservoir, which suggests that kokanee are specific as to the type of organisms on which they feed. Species and size selection by kokanee has been documented by other investigators (Finnel and Reed 1969, Leathe and Graham 1981, Schneidervin and Hubert 1987). During this study, the density of large Daphnia taken by kokanee showed an inverse relationship to the population density of kokanee in the reservoir (refer to Figure 10). It was previously shown that kokanee may exert pressure on Daphnia populations that could lead to increased densities of smaller plankters. For this reason, potential size-specific selection on Daphnia by kokanee was analyzed.

Size selectivity of Daphnia by kokanee appeared to change throughout the seasons (Table 37). Selection for the larger Daphnia increased from winter through summer and then decreased again in the fall. Selectivity index values indicated that selection was primarily for those Daphnia greater than 1.49 mm in all seasons (Table 38) and is similar to those for kokanee in Flathead Lake (Leathe and Graham 1981). The avoidance values for the size class >2.0 mm during winter and spring months is unexplainable except that it may be due to sampling error.

#### Oncorhynchus trout species

Stomachs from 1,080 Oncorhynchus trout (westslope cutthroat, rainbow, and cutthroat X rainbow hybrids) captured in Libby Reservoir from 1983 through 1987 were examined to determine their food habits. Over 90 percent of the stomachs analyzed contained food items. All trout were combined because of the difficulty to positively identify the species in the field. In addition, trout species in Libby Reservoir have similar food habits (McMullin 1979, Huston et al. 1984, Chisholm and Fraley 1986). Trout were also separated by size class (trout <330 mm TL and trout >330 mm TL) as done by McMullin (1979) because of the potential for food preference differences between the sizes.

The diet of trout in Libby Reservoir was similar for all years except 1987 (Table 39). In most years, terrestrial and aquatic insects comprised the majority of the food for all size classes. Trends in feeding preference were also similar for all sizes of trout. Feeding on zooplankton decreased in 1985 and utilization of terrestrial and aquatic invertebrates increased. In addition, zooplankton was absent from the diets of both size classes of trout in 1987. The reason for the lack of zooplankton is not fully understood. As was shown previously, the density of larger Daphnia (the primary zooplankton taken by trout) was considerably lower in 1987 than in 1986. Because of this, the trout may have switched to a more available food source.

There was some seasonal variation in the food habits of trout in Libby Reservoir. This variation was closely related to availability of food items in the reservoir. Zooplankton were most important during the winter months, followed by aquatic

Table 37. Seasonal length group densities (no./l) and mean lengths of Daphnia in plankton tows and ingested by kokanee by season in Libby Reservoir, 1983 through 1987. All lengths are expressed in millimeters.

Season	Length group densities of <u>Daphnia</u> in tows					Mean length		
	<0.49	0.5-0.99	1.0-1.49	1.5-1.99	2.0-2.5	Mean of ingested length	<u>Daphnia</u>	Range
Winter	0.04	0.54	0.47	0.19	0.01	0.84	1.53	1.05-1.85
Spring	0.02	1.49	1.04	0.24	0.01	0.86	1.55	1.16-1.82
Summer	0.01	0.97	0.89	0.31	0.03	0.83	1.96	1.16-2.27
Fall	0.03	1.19	0.94	0.32	0.08	0.83	1.82	1.59-2.04

Table 38. Ivlev's selectivity index for size classes of Daphnia ingested by kokanee by season in Libby Reservoir, 1983 through 1987.

Season	<u>Daphnia</u> size classes (mm)				
	0.0-0.49	0.5-0.99	1.0-1.49	1.5-1.99	2.0-2.5
Winter	-1.0	-1.0	-0.50	0.70	-1.0
Spring	-1.0	-1.0	0.20	0.68	-1.0
Summer	-1.0	-1.0	-0.60	0.53	0.94
Fall	-1.0	-1.0	-1.0	0.72	0.77

Table 39. Index of Relative Importance for food items in the stomachs of trout species captured in Libby Reservoir, 1983 through 1987.

	1983		1984		1985		1986		1987	
Length (mm):	<330	>330	<330	>330	<330	>330	<330	>330	<330	>330
Sample size:	N=78	N=124	N=161	N=160	N=204	N=163	N=49	N=59	N=33	N=24
<b>ZOOPLANKTON</b>										
<u>Daphnia</u>	37	31	40	31	23	10	46	27		
<u>Diaptomus</u>	0		1					4		
<u>Epischura</u>	1	1	3		2		3			
<u>Cyclops</u>	-									
Other	3	3	1	2	1	1				
<b>TERRESTRIAL INSECTS</b>										
Hymenoptera	8	12	5	4	18	18	8	10	8	3
Coleoptera	6	5	12	10	8	10	6	9	14	16
Hemiptera	4	2	2	3	4	3	6	6		1
Hymenoptera	11	6	4	2	5	4	7	7		
Other	7	8	4	3	6	7	4	4		1
<b>AQUATIC INSECTS</b>										
Diptera larvae	0.5	2	2	3	2	3	0.5	2	2	9
Diptera pupae	1	-	4	3	5	8	4	3	27	
Diptera adults	9	6	4	4	4	3	6	6	3	1
Other	4	4	3	4	4	3	3	3	27	1
Insect parts	7	9	10	9	15	23	7	6		46
<b>FISH</b>										
Hybrid trout	-					0.5				
Kokanee		1								
Pearmouth chub	-			6		2		1		
-	-							5		
Redside shiner				3		1		2		
Fish parts	0.5	2		3	1	1		-		6
Debris	2	8	5	8	3	5	1	4	20	12

insects (Table 40). In the spring, there was a considerable shift away from zooplankton to aquatic and terrestrial invertebrates. Coleopterans and dipterans, which showed peak abundances in emergence traps and surface insect tows during spring months, had the highest IRI's. As emergence of dipterans subsided in the summer, terrestrial invertebrates, especially flying ants, became the food of choice. In October and November, zooplankton and terrestrial and aquatic invertebrates were utilized comparably.

### Mountain Whitefish

Stomachs from 225 mountain whitefish captured in Libby Reservoir from 1983 through 1987 were used to determine food habits. There was little variation in food habits among seasons for the whitefish. Daphnia were the most important food items during all seasons (Table 41). There was some variation in the size of Daphnia utilized. The mean length of Daphnia eaten in the fall was considerably greater than in all other seasons which had similar mean lengths. The reason for the increase in size of ingested Daphnia is likely due to a progression in growth of the plankton throughout the year. The greatest densities of larger Daphnia coincide with their utilization by mountain whitefish.

Aquatic and terrestrial invertebrates made up the majority of the remaining food items in all but the winter months. Carlander (1969) suggested that because terrestrial and aquatic insects were the primary food source for mountain whitefish, the utilization of zooplankton may indicate a scarcity of the larger invertebrates. Food habits of mountain whitefish in Libby Reservoir were similar to those found in Flathead Lake (Leathe and Graham 1981) and in Hungry Horse Reservoir (May et al. 1988).

### Bull Trout

Stomachs from 162 bull trout captured in Libby Reservoir from 1983 through 1987 were examined to determine their feeding habits. Fish species were the most important food items for bull trout throughout the year with a combined Index of Relative Importance value of 65 (Table 42). Fish species contributed to more than 99 percent of the total biomass ingested by bull trout. Index values were high for terrestrial and aquatic invertebrates in the spring and summer. Likely reasons for the high values may be due to an artificial inflation of the IRI from high frequency of occurrence and numeric parameters.

Bull trout ingested at least 10 different species of fish found in the reservoir. Collectively, salmonids were the most important species consumed. Kokanee appeared to be the species of most importance to bull trout followed by Oncorhynchus trout species, largescale suckers, and peamouths. The only species not taken by bull trout were burbot and bull trout.

Table 40. Indices of Relative Importance for food items in the stomachs of trout species captured by season in Libby Reservoir, 1983 through 1987.

	Dec.-March		April-June		July-Sept.		Oct.-Nov.		All Months	
Length (mm):	<330	>330	<330	>330	<330	>330	<330	>330	<330	>330
Sample size:	N=53	N=52	N=130	N=126	N=128	N=158	N=214	N=194	N=525	N=530
<b>ZOOPLANKTON</b>										
Daphnia	60	64	14	0	29	24	35	24	31	23
Diaptomus	2					2			0	1
Epiischura	-		2		2	1	3		2	0
Cyclops	-						<1		0	0
Other	-				2	2	2	3	1	2
<b>TERRESTRIAL INSECTS</b>										
Hymenoptera	1	1	9	11	25	25	6	4	13	13
Coleoptera	3	1	17	17	6	5	6	6	2	2
Hemiptera	0		3	3	4	3	4	3	3	3
Hymenoptera	4	2	3	1	6	5	7	6	5	4
Other	3	3	6	7	3	5	6	5	5	6
<b>AQUATIC INSECTS</b>										
Diptera larvae	0	2	3	1	1	1	2	5	2	3
Diptera pupae	4	2	10	13	3	2	1	1	4	4
Diptera adults	4	4	3	2	5	4	5	6	5	4
Other	2	1	1	2	1	1	6	6	3	3
Insect parts	6	4	23	35	11	9	9	10	12	15
<b>FISH</b>										
Hybrid trout	-					1				0.5
Brook chub	-					2	1	5	0.5	2
-	-					1	-	-		
Redside shiner	-						-	3		1
Fish parts	-					2	2	3	0.3	
Debris	8	15	5	6	1	2	4	9	0.1	6
Miscellaneous	1		0	0	0		1	1	0.1	

Table 41. Seasonal Indices of Relative Importance for food items in the stomach of mountain whitefish in Libby Reservoir, 1983 through 1987.

Sample Size:	N=225	N=17	N=66	N=72	N=70
Time Period:	Jan - Dec	Dec - Mar	Apr - Jun	Jul - Sep	Oct - Nov
ZOOPLANKTON					
<u>Daphnia</u>	76	91	66	76	73
<u>Diaptomus</u>	0		1	0	
<u>Epischura</u>	2		4	0	4
Cyclops	0			1	
Other plankton	1			3	
TERRESTRIAL INSECTS					
Hymenoptera	1		1	2	
Coleoptera	0		1		
Hemiptera	0			1	
Homoptera	1		1	1	1
Other insects	0			1	
AQUATIC INSECTS					
Diptera larvae	4	2	3	2	11
Diptera pupae	3		6	2	2
Diptera adult	1		1	0	1
other	0			0	
Insect parts	2		10		
FISH					
Fish parts	0			1	
Debris	5	7	4	5	7
Miscellaneous	2		3	2	2

Table 42. Seasonal Indices of Relative Importance for food items in the stomachs of bull trout in Libby Reservoir, 1983 through 1987.

Sample Size:	N=162	N=7	N=85	N=8	N=62
Time Period:	Jan - Dec	Dec - Mar	Apr - Jun	Jul - Sep	Oct - Nov
TERRESTRIAL INSECTS					
Hymenoptera	1			18	
AQUATIC INSECTS					
Diptera pupae	30		38		
Diptera adult	0		1		
Insect parts	1		1		4
FISH					
Westslope Cutthroat	6	-	1	-	14
Rainbow trout	2	-		-	4
Hybrid trout	2	-		42	3
Kokanee	12	59	5	-	16
Mountain Whitefish	1	-	2	-	
Longnose sucker	0	-	1	-	
Largescale sucker	8	-		-	16
Peamouth chub	7	-	15	-	6
Northern Squawfish	1	-	3	-	
Redside shiner	3	22	3	-	
Yellow perch	2	-	3	10	2
Other fish	0	-	1	-	
Fish parts	21	11	26	12	26
Debris	1	-	1	18	
Other unid.	2	9	1		8

The type of prey taken by bull trout in Libby Reservoir is quite different than that reported for other waters. Leathe and Graham (1981) found that three species of whitefish were important in summer and fall and nongame species important in winter in Flathead Lake. May et al. (1988) found rough fish to be the most important fish species taken in Hungry Horse Reservoir. Carlander (1969) cited several examples of bull trout feeding on sockeye and kokanee salmon.

## **Burbot**

Food habits for burbot were determined by analyzing stomachs from 69 specimens captured in Libby Reservoir from 1983 through 1987. Like bull trout, fish species were the most important food source overall for burbot in Libby Reservoir (Table 43). At least nine species of fish were found in stomachs of burbot including one instance of cannibalism. Larval dipterans were also found to be important.

The bottom-dwelling organisms utilized by burbot attest to their primarily benthic lifestyle. During fall and winter months largescale suckers were the most important fish prey, and dipteran larvae were an important food item during all months, especially in fall.

During spring, yellow perch replaced suckers as the most important food source for burbot. This shift in diet is likely because of their proximity to each other in the spring. Yellow perch spawn in sandy areas in the spring (April - June) when vegetation is scarce (Brown 1971, Scott and Crossman 1975). During that time, yellow perch are likely concentrated in several areas in the reservoir, especially in the Rexford area. This is corroborated by the sinking gill net records, shown previously. The result is a species of fish preferred by burbot (Muth 1973, Scott and Crossman 1975). Yellow perch will likely become increasingly important to burbot if their densities increase.

## **Other Fishes**

Food habits for other fishes captured in Libby Reservoir from 1983 through 1987 are presented in Table 44. Species of greatest interest are northern squawfish, peamouth chubs, and largescale suckers. These are the most likely species to interact with game species because of their high densities in the reservoir and food habits which are similar to those of game species.

Northern squawfish food habits were obtained from spring through fall during the study period. In all seasons, fish were collectively the most important food source for squawfish (Table 45), comprising no less than 90 percent of the total biomass ingested.

Table 43. Seasonal Indices of Relative Importance for food items in the stomachs of burbot in Libby Reservoir, 1983 through 1987.

Sample Size:	N=69	N=12	N=44	N=3	N=10
Time Period:	Jan - Dec	Dec - Mar	Apr - Jun	Jul - Sep	Oct - Nov
AQUATIC INSECTS				NA	
Diptera larvae	29	18	27		43
Diptera pupae	1	-	1		
other	2	-	3		
Insect parts	1	-	1		
FISH				NA	
Westslope cutthroat	1	5	-		-
Kokanee	2	9			-
Mountain whitefish	1		3		-
Burbot	1	4			-
Longnose sucker	1		2		-
Largescale sucker	18	18			37
Peamouth chub	7	11	7		-
Redside shiner	2	4	2		-
Yellow perch	9	4	21		-
Other fish	1		3		-
Fish parts	18	15	26		6
Debris	3	4	2		7
otherunid.	3	7	1		7

Table 44. Indices of Relative Importance for food items in the stomachs of nongame fish species in Libby Reservoir, 1983 through 1987.

Sample Size: Species:	N=170 NSQ <sup>a/</sup>	N=172 CRC	N=53 YP	N=27 FSU	N=46 RSS	N=54 CSU
<b>ZOOPLANKTON</b>						
<u>Daphnia</u>	37	67	44	17	29	56
<u>Diaptomus</u>	1	0	-		1	
<u>Epischura</u>	-		-	3		1
<u>Cyclops</u>	-	-	-	3	1	16
Other plankton	-	-	-		2	3
<b>TERRESTRIAL INSECTS</b>						
Hymenoptera	-	1	-	-	3	1
Coleoptera	-	1	-	-		-
Hemiptera	-	0	-	-		-
Homoptera	-	0	-	-	1	-
Other insects	-		-	-	3	-
<b>AQUATIC INSECTS</b>						
Diptera larvae	1	6	6	39	1	7
Diptera pupae	3	2	6	23	6	6
Diptera adult	-	-	-		1	3
Other	8	0	1	-	22	2
Insect parts	4	4	1	-	27	7
<b>FISH</b>						
Hybrid trout	-	-	-	-	-	-
Kokanee	-	-	-	-	-	-
Peamouth chub	1	-	-	-	-	-
Northern Squawfish	-	-	-	-	-	-
Redside shiner	0	-	-	-	-	-
Fish parts	33	14	38	-	-	-
Debris	1	2	3	15	1	-
Miscellaneous	1	1	-	-	1	-
Other unid.	10	-	-	-	-	-

<sup>a/</sup> NSQ = northern squawfish, CRC=peamouth chub, YP=yellow perch, FSU=longnose sucker, RSS=redside shiner, CSU=largescale sucker.

Table 45. Seasonal Indices of Relative Importance for food items in the stomachs of three nongame fish species in Libby Reservoir, 1983 through 1987.

Species	Dec - March			April - June			July - Sept.			Oct - Nov		
	NSQ <sup>a/</sup>	CSU	CRC	NSQ	CSU	CRC	NSQ	CSU	CRC	NSQ	CSU	CRC
ZOOPLANKTON	NA				NA						NA	
<u>Daphnia</u>	NA	66	34		NA	67	43	83	89	22	NA	68
<u>Diaptomus</u>	NA				NA		1		1		NA	
<u>Epischura</u>	NA				NA			1			NA	
<u>Cyclops</u>	NA	11			NA			1			NA	
Other plankton	NA				NA		1	4			NA	
TERRESTRIAL INSECTS												
Hymenoptera	NA				NA	3			1		NA	
Coleoptera	NA				NA	3			-		NA	2
Hemiptera	NA				NA				-		NA	2
Homoptera	NA				NA				1		NA	
AQUATIC INSECTS												
Diptera larvae	NA	11	20	2	NA	2	1	4	2		NA	16
Diptera pupae	NA	11		33	NA	8		1	1		NA	
Diptera adult	NA				NA			3	-		NA	
other	NA			5	NA		5	-	1	28	NA	
Insectparts	NA			7	NA	9	5	1	2	2	NA	4
FISH												
Peamouth chub	NA			3	NA				-		NA	
Redside shiner	NA			2	NA				-		NA	
Fish parts	NA		46	44	NA		17		-	34	NA	
Debris	NA			2	NA	1			2	6	NA	8
Miscellaneous	NA				NA	6				7	NA	
Unidentified	NA			3	NA		27				NA	

<sup>a/</sup> NSQ=northern squawfish, CSU=largescale sucker, CRC=peamouth chub.

It was impossible to assess specific food habits of northern squawfish from Libby Reservoir because of the high percent of empty stomachs (47 percent) and the advanced state of digestion in all but two of the stomach samples. Other authors (Carlander 1969, Brown 1971, Gray et al. 1982, and May et al. 1988) noted the potential for predation by northern squawfish on young salmonids.

Peamouth chubs were consistent in their choice of Daphnia (mean length = 1.70 mm) as a primary food source. Index of Relative Importance values were greater than 65 in all seasons except winter when unidentified fish species were most important. We found no literature to suggest that piscivory might be common to peamouths, but Brown (1971) suggested peamouths may occasionally feed on small fish. Aquatic, and to a lesser extent terrestrial, invertebrates comprised the majority of the remaining prey consumed by peamouth chubs in Libby Reservoir.

It was important to analyze food habits of largescale suckers because of their relatively high utilization of Daphnia. Daphnia was the most important food source for largescale suckers in all seasons in which they were captured. Zooplankton collectively comprised an IRI value of 76 throughout the study period and values were as high as 89 during the spring season.

#### Shoener Overlap Index

The Shoener index of dietary overlap was determined for all species of fish that were collected for food habits analysis in Libby Reservoir during the study period. The purpose of the index was to show possible interspecific competitive relationships or community structures. Some ambiguities have been related to combinations of diet measures and dietary overlap indices (Wallace 1981). For this reason, the Shoener index was based on average weights of food items found in the stomachs. This combination probably more closely parallels caloric intake of each food item.

Because of the wide variety of prey preferences for fish in Libby Reservoir, and probability of low index values for some food items, specimens were separated into two groups. The first group contained those fish that were considered to be primarily non-piscivorous based on initial analysis of stomach samples and the work of several other researchers (Carlander 1969, Brown 1971, Scott and Crossman 1973). Group two included all species that were found to have fish in any stomachs.

Very little overlap occurred among the non-piscivorous fish (Table 46). Overlap index values ranged from a low of 0.11 between redbreasted shiners and large-scale suckers to a high of 0.95 between mountain whitefish and largescale suckers. With respect to game species, kokanee and mountain whitefish were the only two species to show a high index value (0.90). In addition, these two species overlapped considerably with largescale suckers (0.93 and 0.95 for kokanee and mountain whitefish, respectively). The most common food item for all these species was zooplankton.

Table 46. Shoener index values of dietary overlap for eight species of fish considered to be primarily non-piscivorous from Libby Reservoir, 1983 through 1987.

	Trt <sup>a/</sup>	Csu	yp	Rss	Crc	Mwf	Fsu
Kok	0.19	0.93	0.13	0.05	0.53	0.90	0.24
Trt		0.25	0.26	0.36	0.43	0.31	0.53
Csu			0.20	0.11	0.54	0.95	0.31
YP				0.07	0.21	0.18	0.27
R S S					0.15	0.13	0.76
Crc						0.56	0.35
Mwf							0.32

<sup>a/</sup> Kok = kokanee, Trt = Oncorhynchus trout species, Csu = largescale suckers, Yp = yellow perch, Rss = redbside shiners, Crc = Peamouth chubs, Mwf = mountain whitefish, Fsu = long-nose suckers.

Kokanee, mountain whitefish, and largescale suckers consumed zooplankton as 99.1, 86.4, and 92.5 percent, respectively, of their total biomass intake (Table 47). Daphnia were the most important zooplankton taken by each of the fish species. Both percent of total weight and mean lengths of Daphnia ingested were similar for kokanee and mountain whitefish. The percent weight of Daphnia ingested was lower for largescale suckers, although the mean lengths of Daphnia found in their stomachs were similar

The high Shoener index values, similar percent biomasses, and mean lengths of Daphnia in the stomachs of the three species suggest a potential for interspecific competition. Kokanee are well known for their preference of cladocerans as a food source (Collins 1971, Rieman and Bowler 1980, Leathe and Graham 1981). Mountain whitefish also prey heavily on crustacean zooplankton (Scott and Crossman 1973, May et al. 1988). In addition, largescale suckers of all sizes, especially juveniles, are known to feed heavily on zooplankton and also may feed on kokanee eggs (Carlander 1969, Brown 1971, Scott and Crossman 1973).

Many dissimilarities exist among the three species that may suggest little competition in Libby Reservoir. Largescale suckers commonly occupy areas close to the substrate and near shore as do mountain whitefish (Scott and Crossman 1973, and section on tertiary production in this report), while gillnetting in Libby Reservoir has shown that kokanee are primarily limnetic. Largescale suckers are also different from the other species in that they feed heavily on the copepod Cyclops in Libby Reservoir.

Godfrey (1955) found that mountain whitefish fed on limnetic plankton mostly when bottom organisms were scarce and that in those instances, whitefish were commonly at low population densities. Based on netting data, whitefish densities also appear to be low in Libby Reservoir. These different characteristics of the three species suggest that there is some spatial separation and feeding mechanism differences that probably keep the three species from competing directly with each other.

Although the Shoener index for Oncorhynchus trout and kokanee was relatively low (0.19) when the entire year was considered, there was some overlap seasonally. For most of the year, trout and kokanee showed little diet overlap (Table 48). During spring and summer, trout fed more on terrestrial and aquatic invertebrates than did kokanee. In the fall months, fish species (mostly peamouth chubs, redbreasted shiners and northern squawfish) also became important in the diet of trout. During this same time, kokanee fed primarily on zooplankton.

An overlap index value of 0.85 for trout and kokanee occurred in the winter months and involved primarily zooplankton. However, intense competition probably did not occur between trout and kokanee for the following reasons: (1) utilization of zooplankton by both species may have caused the index to be artificially high because of the numeric parameter; (2) mean lengths of Daphnia ingested by trout were considerably greater than those taken by

Table 47. Percent of biomass and mean lengths (mm) of zooplankton types ingested by three species of fish in Libby Reservoir, 1983 through 1987.

Species	Daphnia		Diaptomus		Epischura		Cyclops	
	Percent biomass	Mean length	Percent biomass	Mean length	Percent biomass	Mean length	Percent biomass	Mean length
Kokanee	84.5	1.71	10.2	1.23	4.0	1.25	—	—
Mountain whitefish	85.1	1.78	LO	1.16	1.3	—	—	—
Largescale sucker	53.9	1.83	—	—	1.3	1.08	38.6	—

Table 48. Seasonal Indices of Relative Importance for food items in the stomachs of Oncorhynchus trout species and kokanee in Libby Reservoir, 1983 through 1987.

Timeperiod:	Dec - Mar		Apr - Jun		Jul - Sep		Oct - Nov	
Spp:	Trout	Kok	Trout	Kok	Trout	Kok	Trout	Kok
Sample Size:	N=109	N=105	N=264	N=87	N=88	N=135	N=419	N=59
<b>ZOOPLANKTON</b>								
<u>Daphnia</u>	61	65	7	72	27	93	28	78
<u>Diaptomus</u>	1	34		12	1		0	2
<u>Epischura</u>		0	1	2	1	6	2	16
<u>Cyclops</u>					0		0	
Other plankton					2	0	2	
<b>TERRESTRIAL INSECTS</b>								
Hymenoptera	1		11	0	25		5	1
Coleoptera	2	1	17	0	6		6	-
Hemiptera	0		3		3		3	-
Homoptera	3		2		6		7	-
otherinsects	3		6	1	4		6	1
<b>AQUATIC INSECTS</b>								
Diptera larvae	1		2	2	1		3	-
Diptera pupae	3		11	8	2	1	1	-
Diptera adult	4		3		5		6	-
other	2		1		1		6	-
Insect parts	5		29	3	10	0	10	1
<b>FISH</b>								
Hybrid trout					0			-
Kokanee					0			-
Peamouth chub					1		3	-
Northern Squawfish					1			-
Redside shiner					0		2	-
Fish parts			0		1		3	-
Debris	11		6		1		6	1
Miscellaneous	1		0				1	
Other unid.					0		1	

kokanee (1.70 mm and 1.48 mm, respectively): and (3) alternative food items appeared to be species specific. Trout continued to feed on aquatic, and to a lesser extent terrestrial, invertebrates while kokanee utilized Diaptomus as an important secondary food source.

Many of the fish species from Libby Reservoir that showed piscivorous tendencies were found to have high Shoener index values (Table 49). High overlap values were seen among bull trout, burbot, northern squawfish, and yellow perch. The combined Oncorhynchus trout species showed little diet overlap with any of the other piscivorous species.

Because of the amount of digestion that had occurred in the stomachs of most piscivorous species, direct comparisons were only possible between bull trout and burbot. Both species preyed on all of the potential forage fish in the reservoir, although proportions of prey consumed were different (Table 50). Bull trout fed on ten species of fish but concentrated on four. The most important prey for bull trout -- in decreasing order of percent biomass -- were kokanee, largescale suckers, trout species, and peamouth chubs. Burbot concentrated on three forage fish species and the order of importance in terms of biomass was largescale suckers, yellow perch, and peamouth chubs.

These differences in prey species suggest differences in feeding strategies between bull trout and burbot. Burbot tends to be bottom dwellers and opportunistic (Scott and Crossman 1973, Muth 1973). Largescale suckers and yellow perch also tend to be bottom dwellers, especially the suckers. In contrast, bull trout in Libby Reservoir are commonly found in open water during most of the year and around the shoreline during summer and fall when they begin spawning movement. This is likely the reason why kokanee and trout species make up almost one-half of the total biomass eaten by bull trout.

As discussed above, poor stomach samples made it impossible to determine any specific correlations between most piscivores and the prey species they consumed. Although May et al. (1988) also found a high Shoener index value for bull trout and northern squawfish, they considered competition unlikely. With respect to Libby Reservoir, continued examination of piscivore stomachs is needed to more fully understand their food and feeding habits. This is especially true with the recent introduction of another potential predator, the Kamloops rainbow trout.

## MIGRANT TRAPPING IN YOUNG CREEK

### Introduction

Young Creek, tributary to Libby Reservoir, is situated 5 km south of the Montana-British Columbia border, and drains a 120 sq km basin of the Purcell Mountains. The stream is 17 km long, and median annual low and high flows range from 5 to 100 cfs,

Table 49. Shoener index values of dietary overlap for five species of fish that utilized fish as a food source from Libby Reservoir, 1983 through 1987.

	Burbot	Trout species	Northern squawfish	Yellow perch
Bull trout	0.99	0.30	0.98	0.84
Burbot		0.17	0.98	0.85
<u>Oncorhynchus</u> Troutspecies			0.20	0.30
Northern squawfish				0.87
.				

Table 50. Percent biomass and percent frequency of occurrence of individual fish species found in the diets of bull trout and burbot from Libby Reservoir, 1983 through 1987.

Species	Bull trout		Burbot	
	Percent biomass	Frequency of occurrence	Percent biomass	Frequency of occurrence
<u>Oncorhynchus</u>				
Trout species	21.5	6.9	2.5	2.0
Kokanee	26.3	7.8	3.7	3.9
Mountain whitefish	1.1	0.9	1.2	2.0
Burbot	--	--	1.2	2.0
Longnose sucker	0.3	0.9	0.7	2.0
Largescale sucker	22.0	1.7	53.9	3.9
Peamouth chub	10.0	8.6	9.0	13.9
Northern squawfish	1.2	1.7		--
Redside shiner	1.3	4.3	1.4	3.9
Yellow perch	1.6	3.4	9.3	15.7
Unidentified fish parts	14.1	49.1	15.0	45.1

respectively. Young Creek has been used as a test stream for evaluating the feasibility of establishing spawning runs of westslope cutthroat trout in tributaries to the reservoir. Management activities in Young Creek have included removal of migration barriers, chemical treatment of 11 km of the headwaters with rotenone, and annual imprint plantings of about 50,000 young-of-the-year westslope cutthroat trout per 300 m of stream from 1970 to 1975.

### Methods

An upstream box trap and a downstream Wolf-type trap (Huston et al. 1984) were operated in Young Creek between 1970 and 1987. The trap structure is located about 100 m upstream from the full pool elevation of Libby Reservoir. The dates of operation varied between years. During certain periods workers were on site 24 hours a day to ensure that debris and peak flows did not interfere with trapping efficiency.

### Results and Discussion

Migratory trout have been captured in bi-directional traps in Young Creek in all years since 1970, except for 1980 and 1981. Results of the trapping are summarized in Table 51. The duration of upstream and downstream trapping periods, and the effort expended in trapping each year were not equal. This disparity precludes standardizing total catches between years. Comparisons made on the basis of daily catch rates are also inappropriate since run strength on a given day in a spawning period varies with discharge and temperature.

Migrants caught in the first three years of trapping in 1970, 1971, and 1972, were considered to be residents of the Kootenai River. The increases in adult captures from 1970 to 1972 were probably the result of the removal of migration barriers in Young Creek. None of the fish caught in those three years were allowed to pass beyond the trap. The post-1973 migrants were therefore considered to be largely the products of reservoir and Young Creek plantings.

Huston et al. (1984) estimated the one year survival of young-of-the year cutthroat planted in fall 1972 to be about 42 percent. Results of the plantings are evident in the period from 1973 to 1977 in which the numbers of adult cutthroat captures increased from 102 to 679. The captures in 1978 are not considered representative since trapping was terminated before the spawning run normally begins. The trap was removed in 1978 on May 3, and Huston et al. (1984) stated that the run normally occurs throughout the month of May.

Captures in 1979, 1980, 1983, and 1984 were fairly similar, but roughly half the size of the 1976 and 1977 peak. In the years 1985, 1986, and 1987, there were substantial reductions in adult captures. The number of adults captured in 1987 was the lowest since 1972.

Table 51. Summary of migratory trout captures in upstream and downstream traps in Young Creek, 1970 through 1988.

Year	Number of days trap operable and dates out- migrant and in- migrant traps were in place	upstream migrants <u>captured</u> adults	Downstream migrants captured	
			adults	juveniles
1970	90 ( 5/5- 6/ 3) (4/16- 7/29)	21	8	498
1971	33 (4/26- 5/29) (4/ 7- 7/21)	57	4	134
1972	42 (4/27- 6/ 9) (3/17-11/13)	90	4	352
1973	50 (4/21- 6/10) (4/ 6- 9/20)	102	32	1408
1974	65 (4/29- 7/ 2) (4/ 1-10/ 3)	229	92	1558
1975	57 (5/13- 7/ 9) (4/16- 7/29)	281	205	1341
1976	42 (5/ 7- 6/18)	692	?	?
1977	36 (4/28- 6/12)	679	3	276
1978	31 (4/ 3- 5/ 3)	3	---	---
1979	69 (5/ 1- 6/14) (5/30- 6/15)	315	126	236
1980	88 (4/ 1- 6/30) (5/20 -8/16)	367	204	1853
1983	80 (6/ 6- 7/18) (4/21- 6/ 8)	260	152	1612
1984	218 (4/10-11/14)	354	227	1330
1985	77 (5/ 2- 7/18)	71	52	1280
1986	54 (4/30- 6/22) (4/30- 8/29)	65	79	1930
1987	48 (4/28- 6/15) (5/18- 7/16)	56	33	596

Huston et al. (1984) offer the following explanations for the declining spawning populations in Young Creek: (1) increased angler harvest in Young Creek; (2) deterioration of habitat quality in Young Creek from human development and forest management; (3) cessation of imprint planting in Young Creek; and (4) decreased survival of Young Creek cutthroat in the reservoir.

An additional factor may be the mortality and stress that the long-term trapping program itself imposes on the Young Creek spawning population.

## RECOMMENDATIONS

1. The effects of the deep drawdown in 1988 and 1989 should be thoroughly researched to document its impact on the reservoir fishery.
2. Continue to develop and implement strategies to evaluate and refine the model from 1988 through 1992. This will increase the predictive capability and therefore usefulness of the model.
3. Refine the annual hydroacoustic estimate through the use of dual-beam echo-sounding equipment.
4. Emphasize data collection to address system variables and trophic level interactions. An example of a critical variable not fully researched in Libby Reservoir is the reservoir hydraulics. This variable directly affects primary production and may influence all trophic levels - even fish distribution and predation rates. An example of trophic level interactions that may be critical in Libby reservoir are the interplay between Daphnia diel vertical distribution, kokanee activity patterns and reservoir hydraulics. It would also be desirable to more closely quantify surface insect deposition using floating insect traps.
5. Emphasize collection of data on peamouth age, growth, food habits and interactions with other fish species. The peamouth is numerically the most important fish in Libby Reservoir and its numbers are apparently increasing. The status of the Kamloops rainbow trout, bull trout and northern squawfish and their feeding habits should continue to be monitored as closely as possible.
6. Evaluate the timing and significance of fish entrainment through the Libby Dam turbines. This information can be used to link the reservoir and river fishery.
7. The effects of dam operation the Kootenai River fishery should be investigated beginning in 1990. Once effects are determined, the model can be used to evaluate and recommend dam operations that will optimize the river and reservoir fishery. Investigations on the Kootenai River should include: (a) Instream Flow Incremental Methodology (IFIM) work on the river channel; (b) habitat suitability investigations on rainbow, bull trout, mountain whitefish and burbot; (c) creel surveys; and (d) investigation on the rate of delta formation at the mouth of tributaries. This work will address program measures 903(b)(1,3), 903(a)(6), 903(d) and 903(e)7 in the 1987 Fish and Wildlife program.

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APPENDIX A  
Figures A1 through A7

Hydrologic characteristics of Libby Reservoir,  
1983 through 1987.

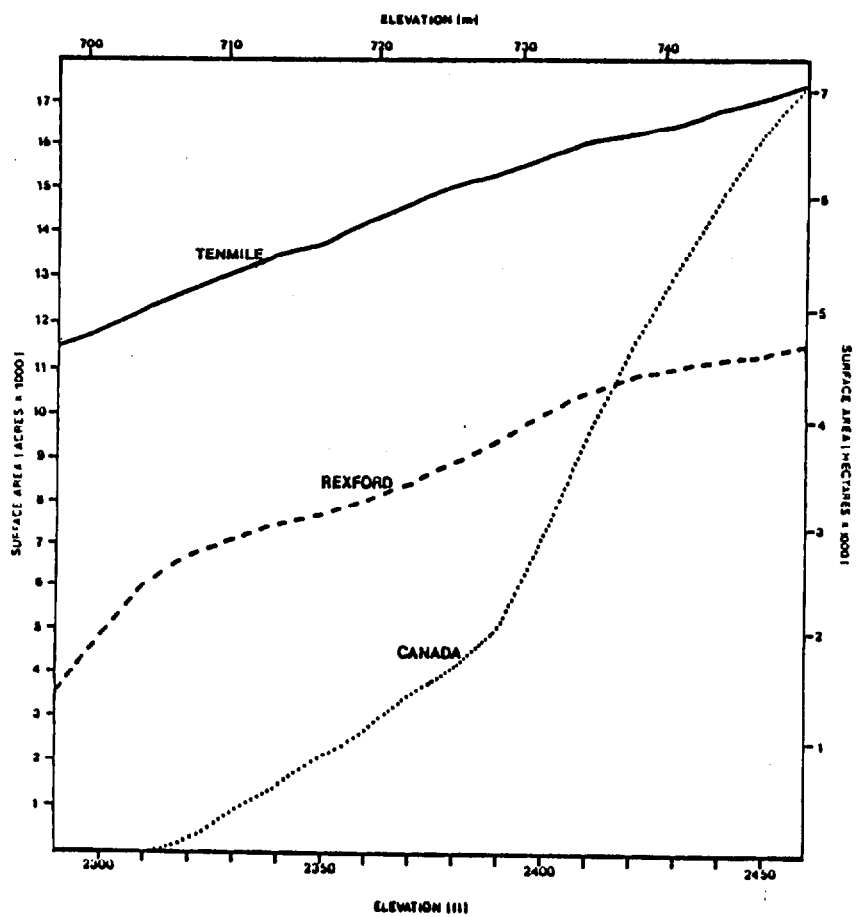


Figure A1. Relationship of Libby Reservoir surface elevation (feet) to area (mega acre feet).

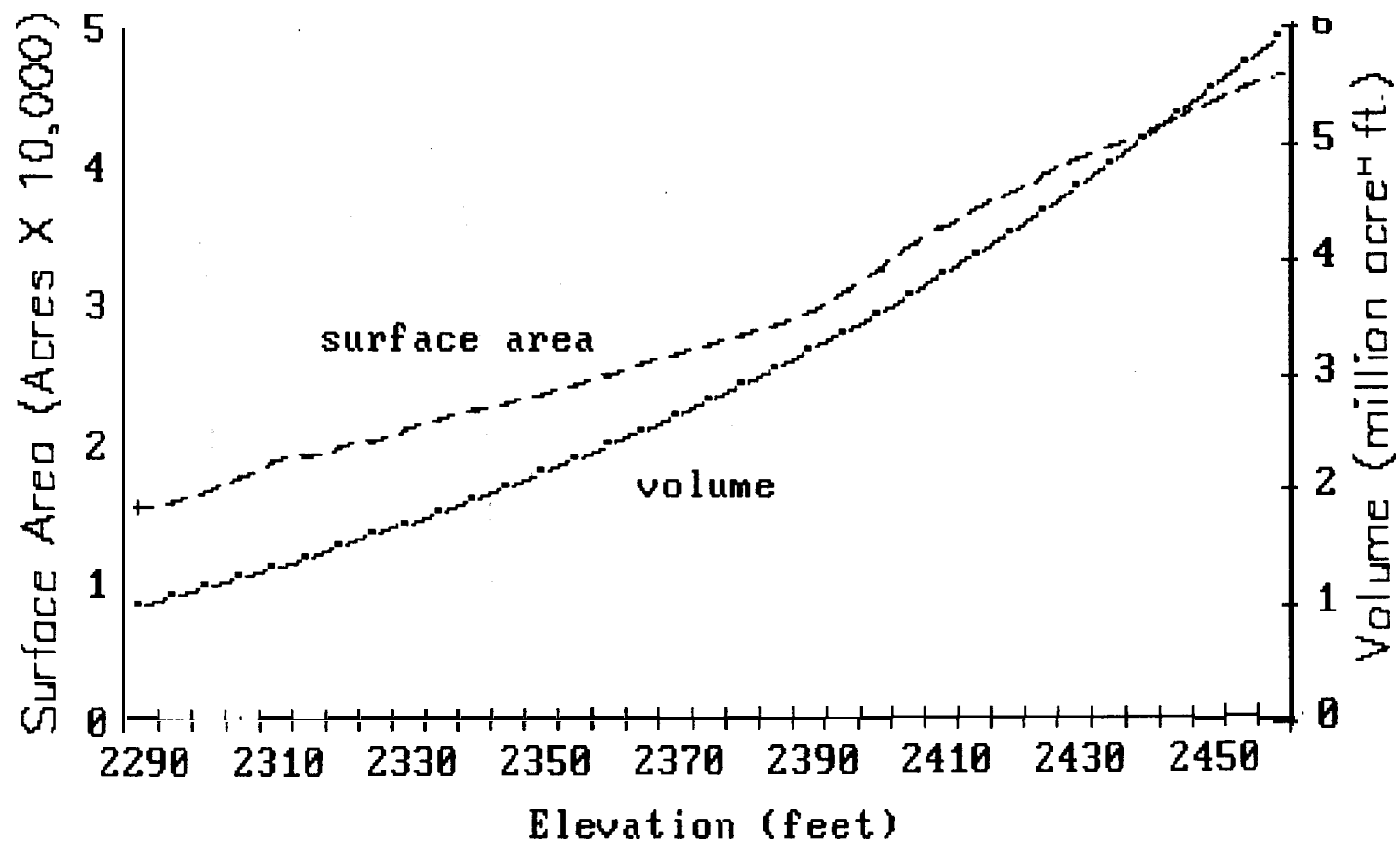


Figure A2. Relationship of Libby Reservoir surface elevation (feet) to volume (million acre-ft) and surface area (acres x 10,000).

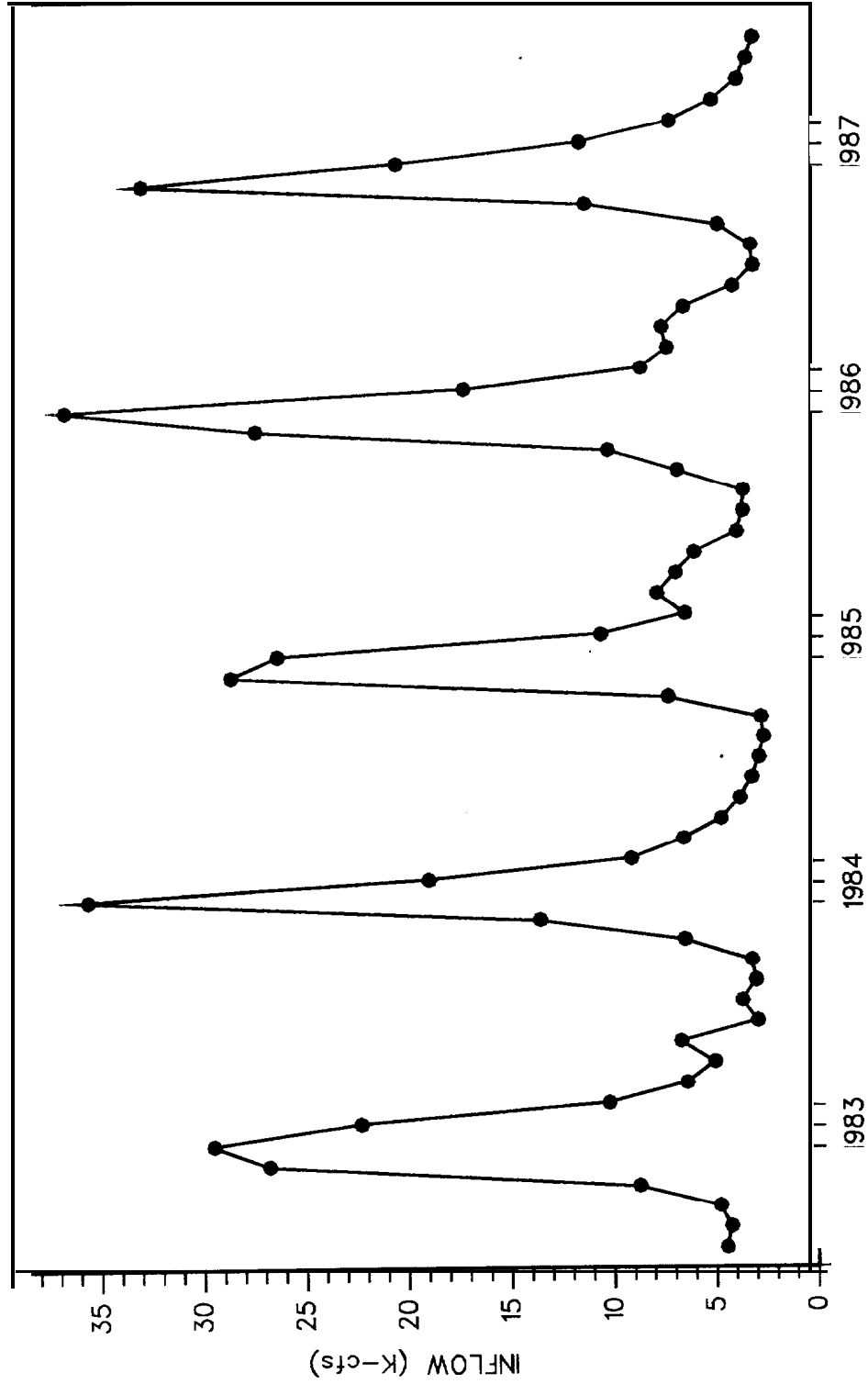
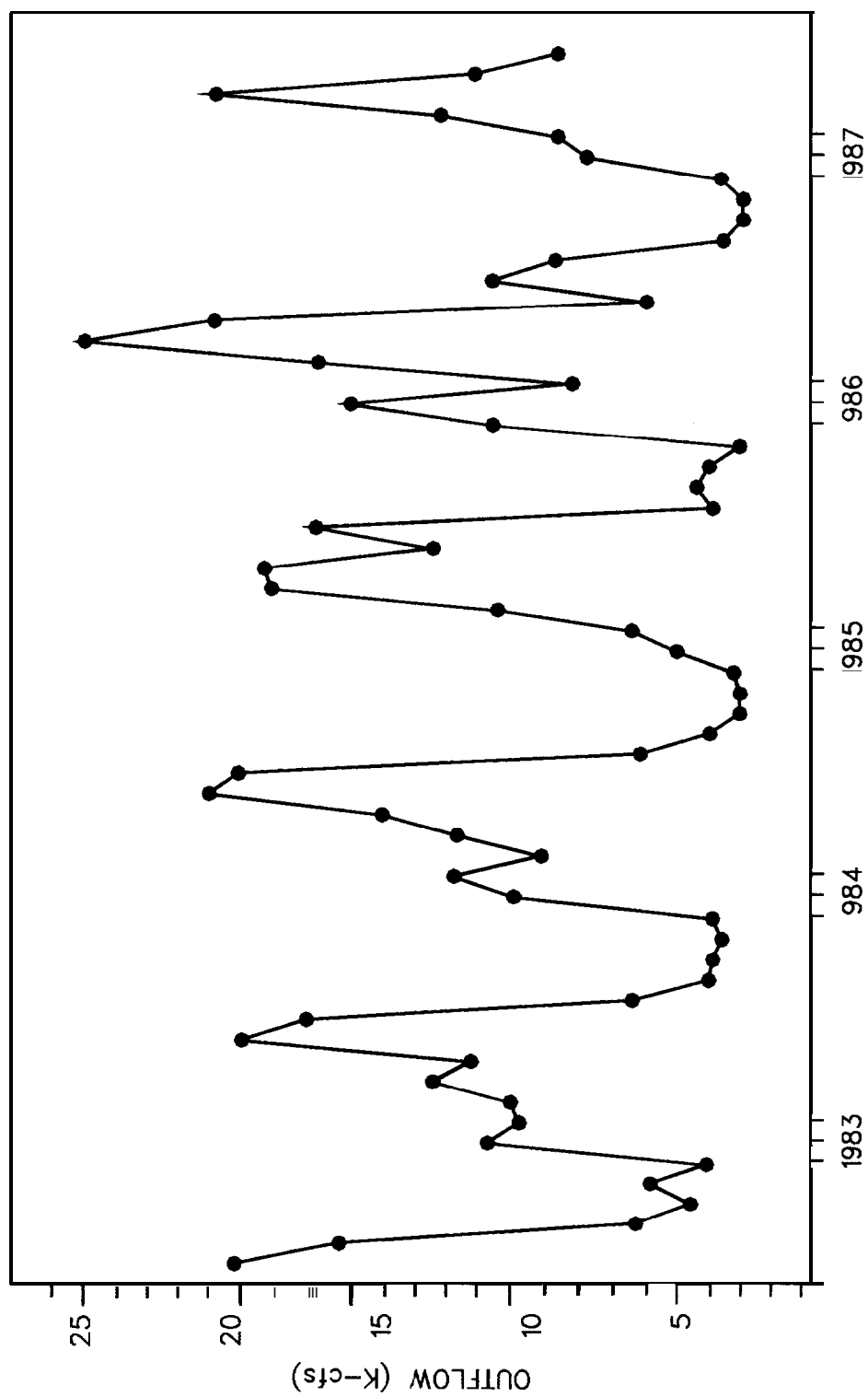


Figure A3 Mean monthly inflow to Libby Reservoir, 1983 through 1987.



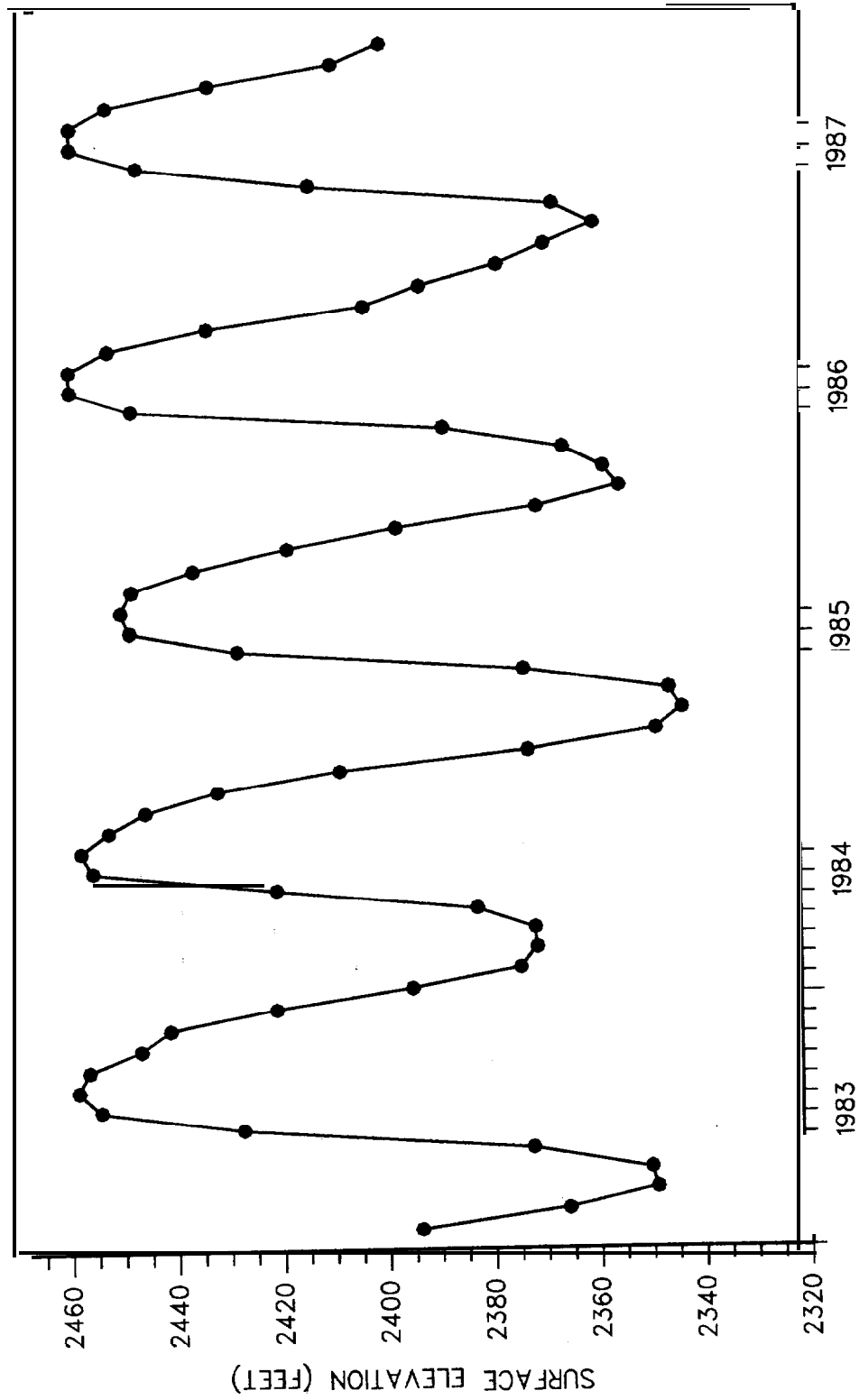


Figure A5. Mean monthly surface elevations (feet above msl) for Libby Reservoir, 1983 through 1987.

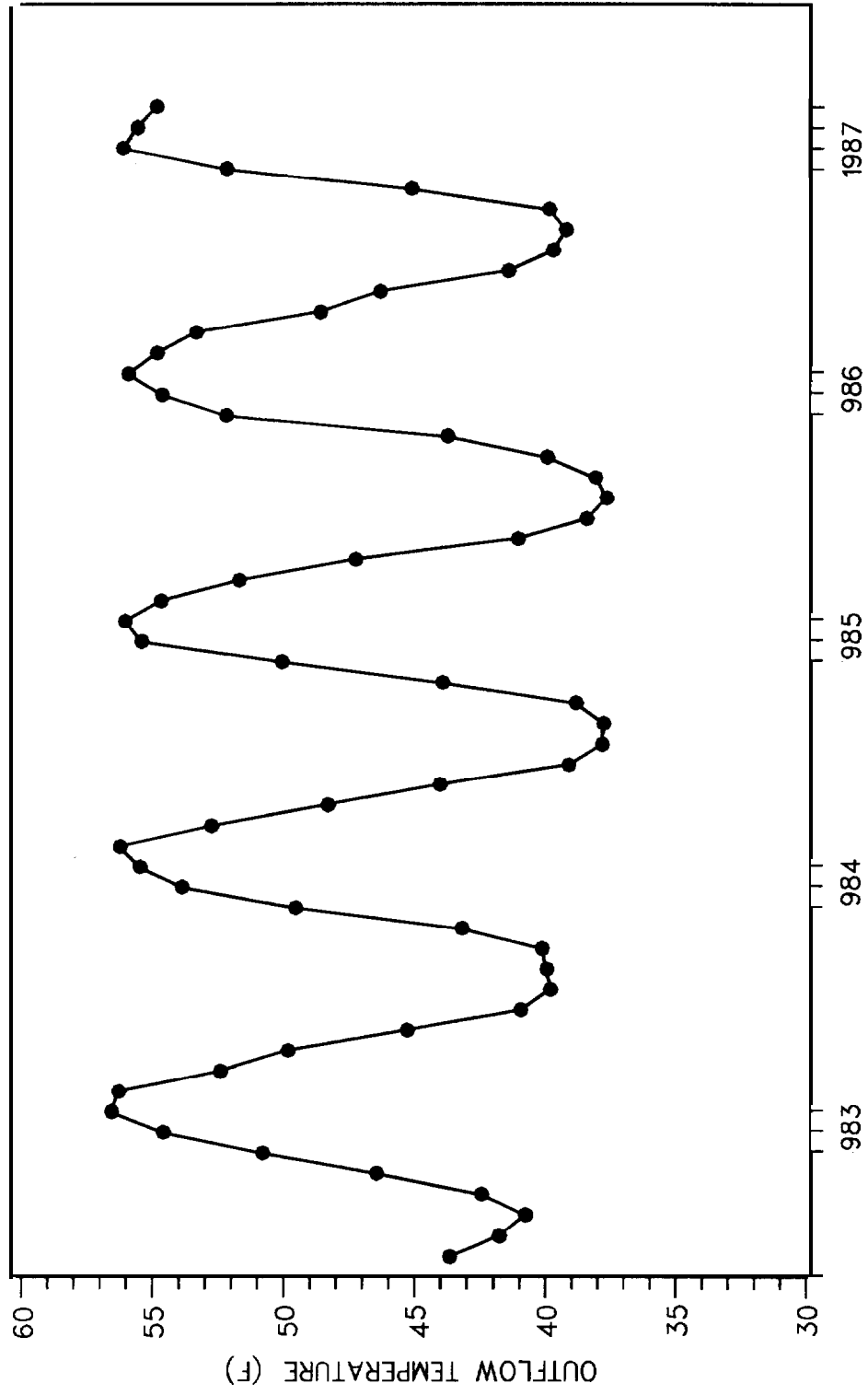


Figure A6. Mean monthly temperature of discharge at Libby Dam, 1983 through 1987.

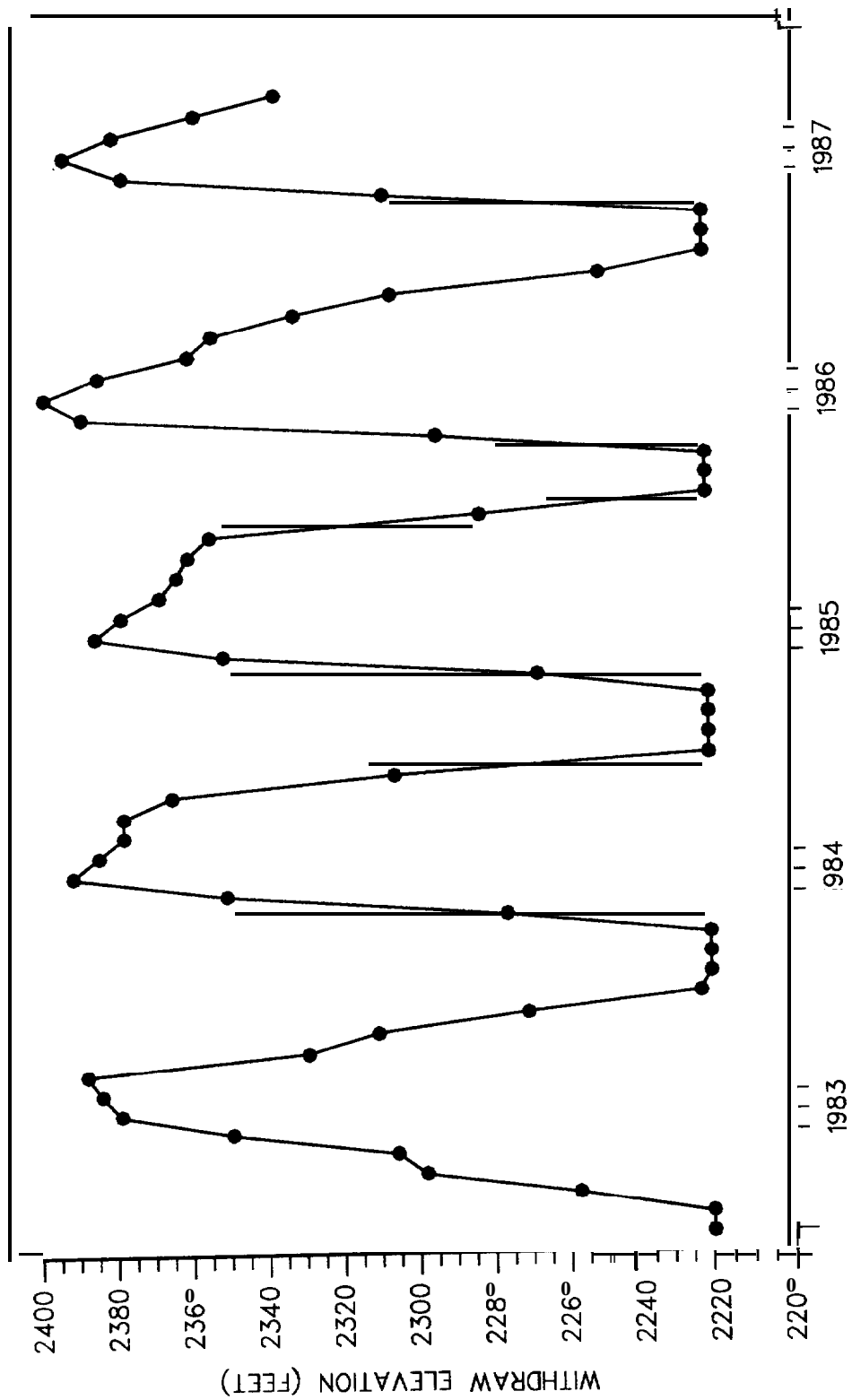


Figure A7. Depth of discharge withdrawal at Libby Dam, 1983 through 1987 Data provided by Army Corps of Engineers.

APPENDIX B  
Figures B1 through B12

Water quality parameters for three study areas  
of Libby Reservoir, 1987.

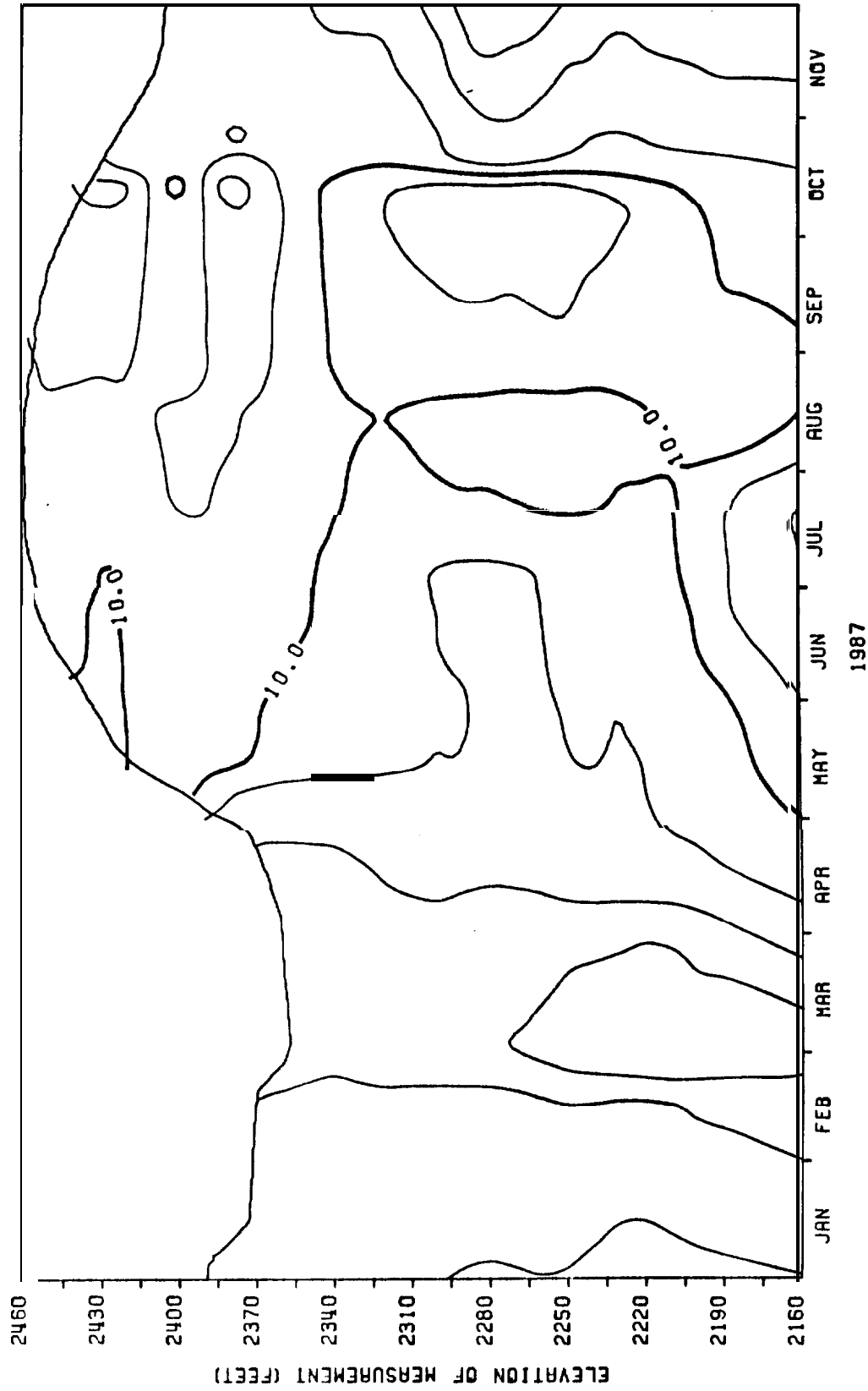


Figure B1. Dissolved oxygen content (mg/l) at reservoir elevation and depth in the Tennessee area of Libby Reservoir, 1987.

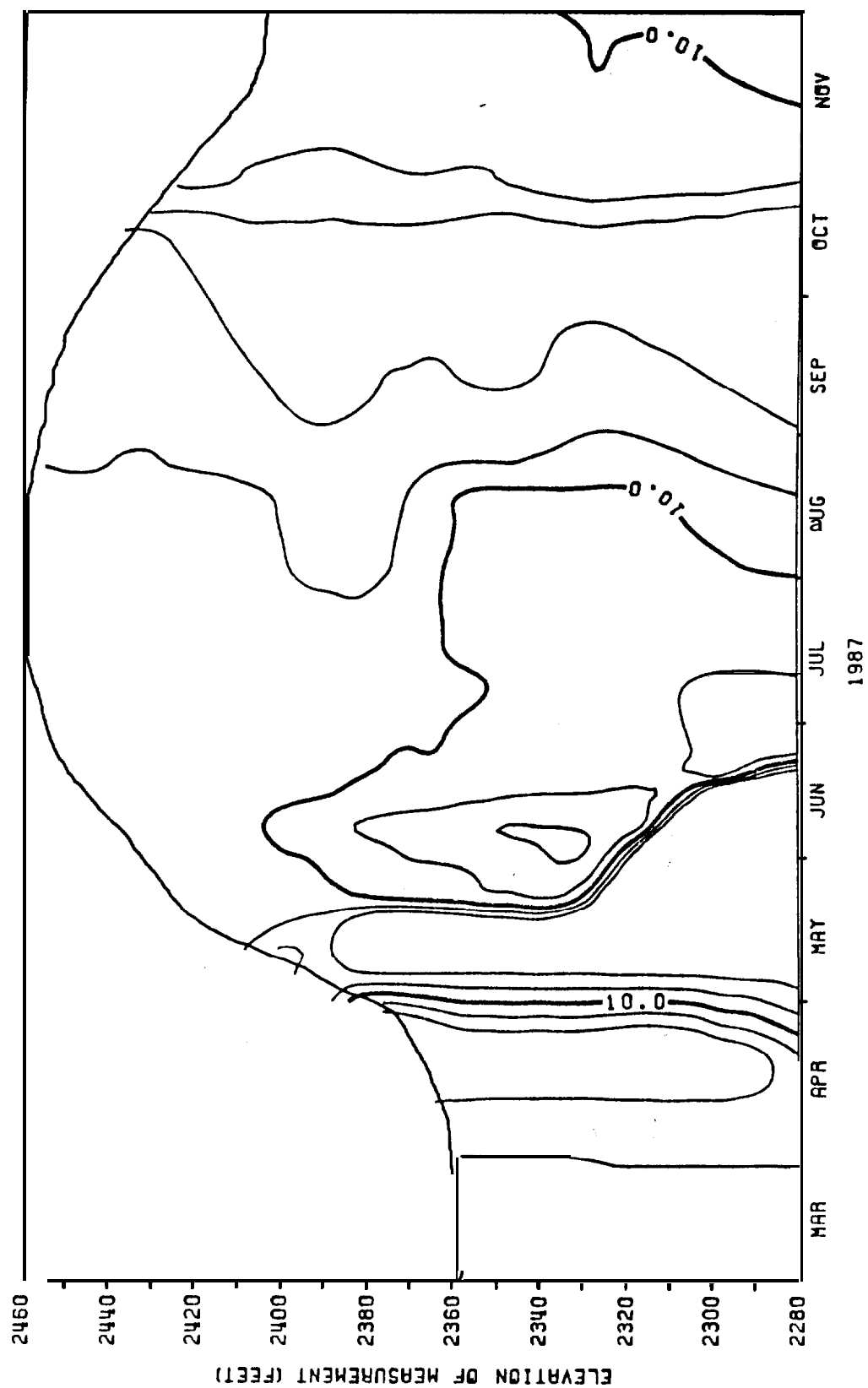


Figure B2. Dissolved oxygen content (mg/l) at reservoir elevation and depth in the Rexford area of Libby Reservoir, 1987.

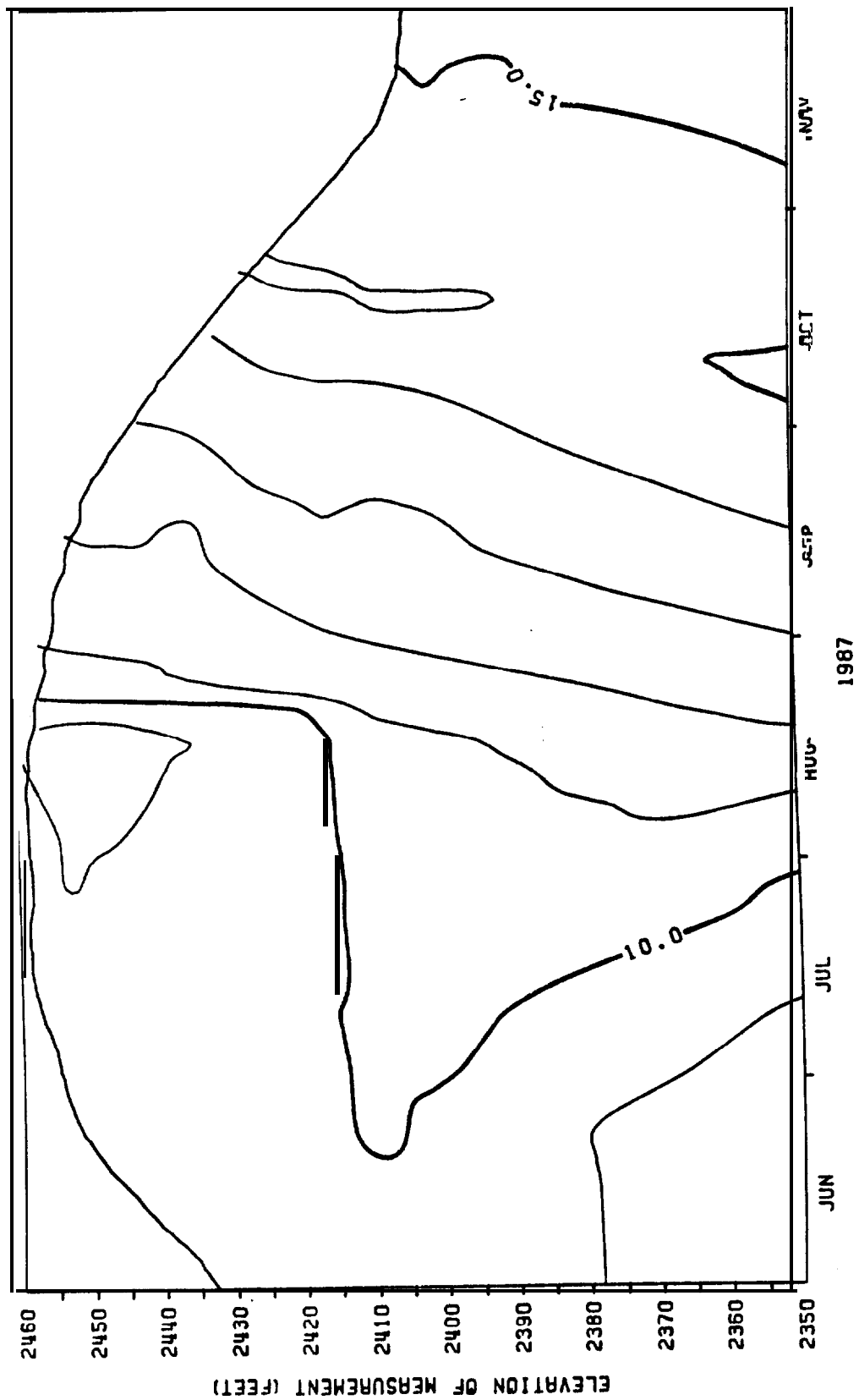


Figure B3. Dissolved oxygen content (mg/l) at reservoir elevation. and depth in the Canada area of Libby Reservoir, 1987.

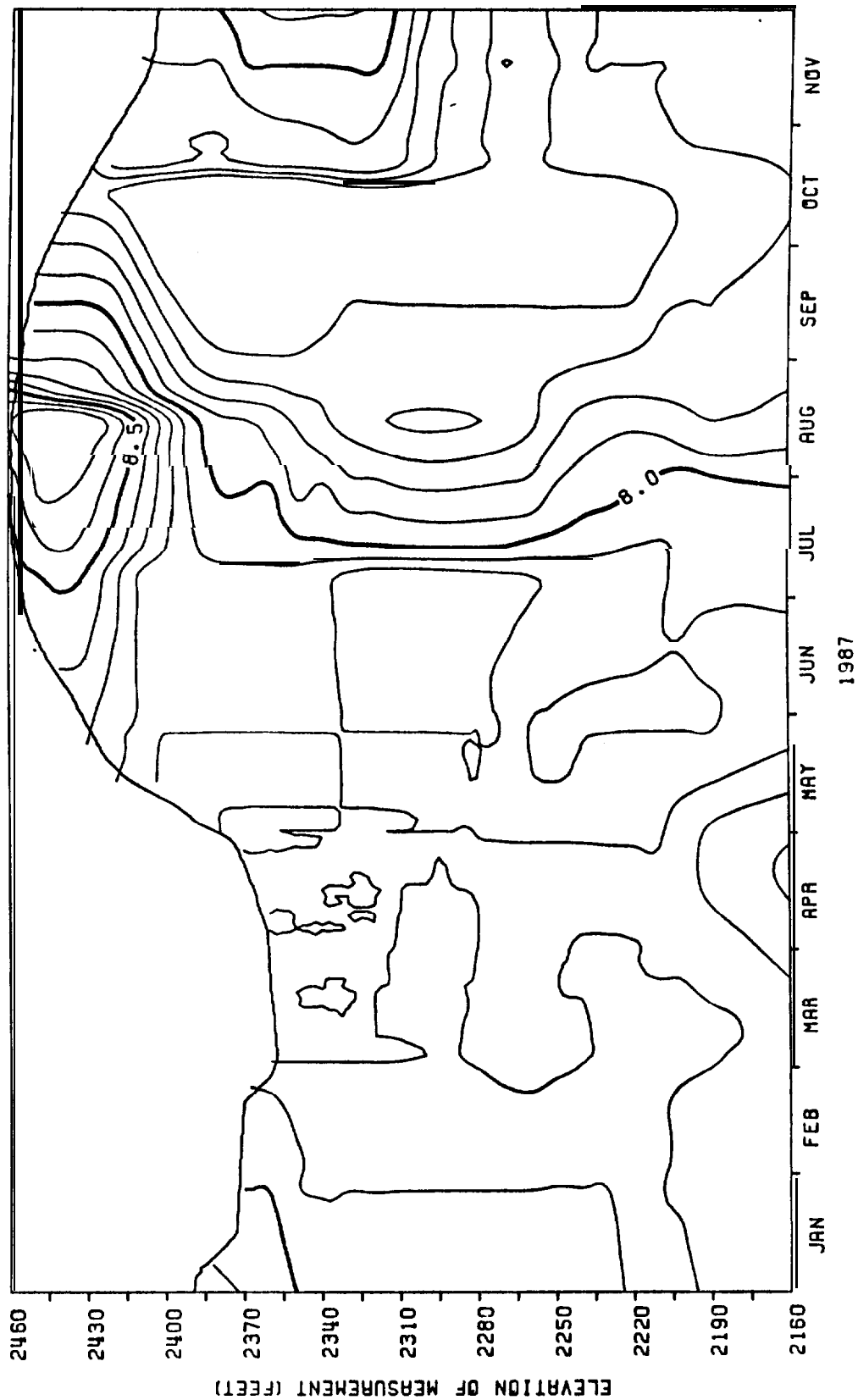


Figure B4. Measurements of pH (0.1) at reservoir elevation and depth in the Teton area of Libby Reservoir, 1987.

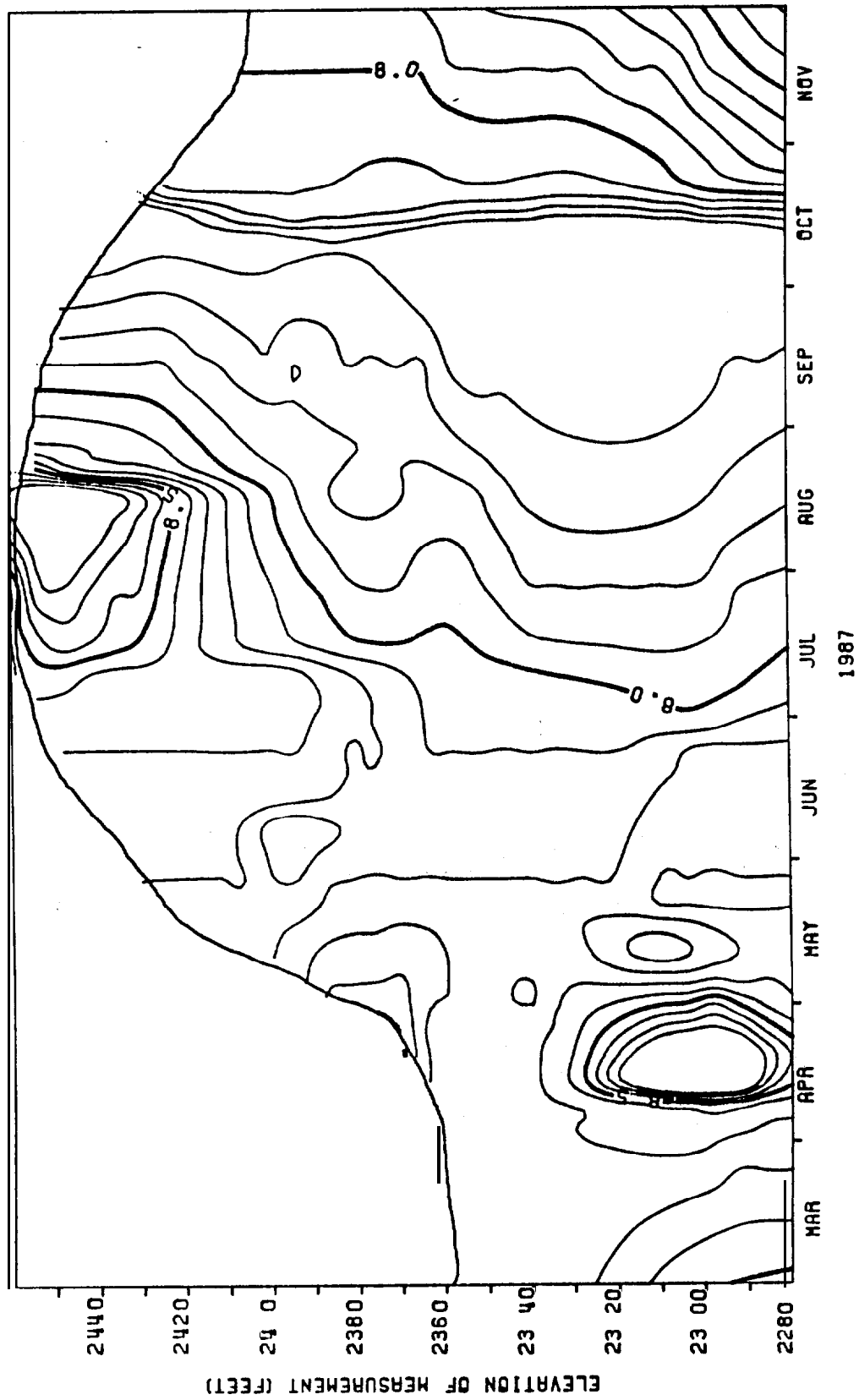


Figure B5. Measurements of pH (0.1) at reservoir elevation and depth in the Rexford area of Libby Reservoir, 1987.

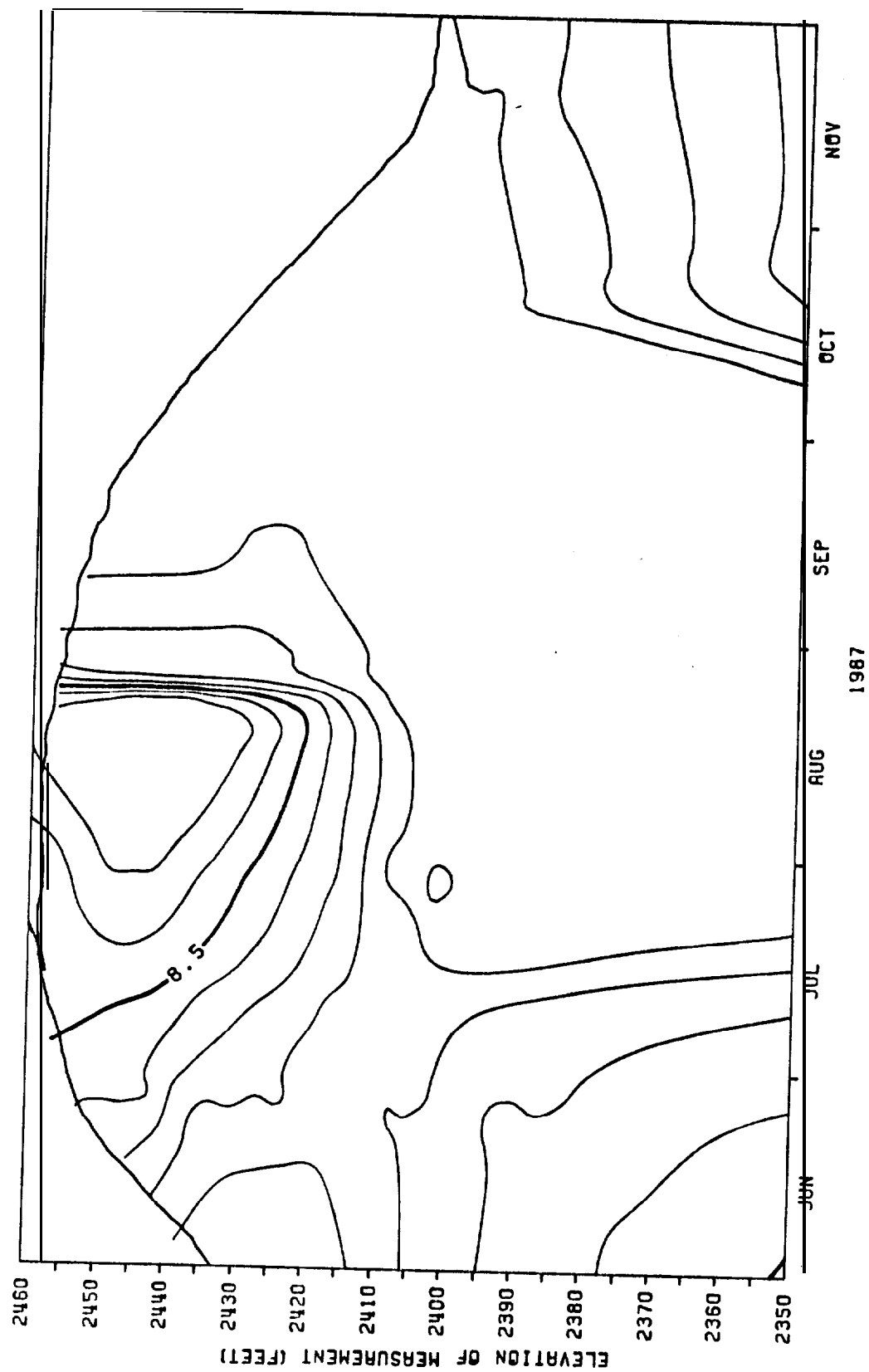


Figure B6 Measurements of pH (0.1) at reservoir elevation and depth in the Canada area of Libby Reservoir, 1987.

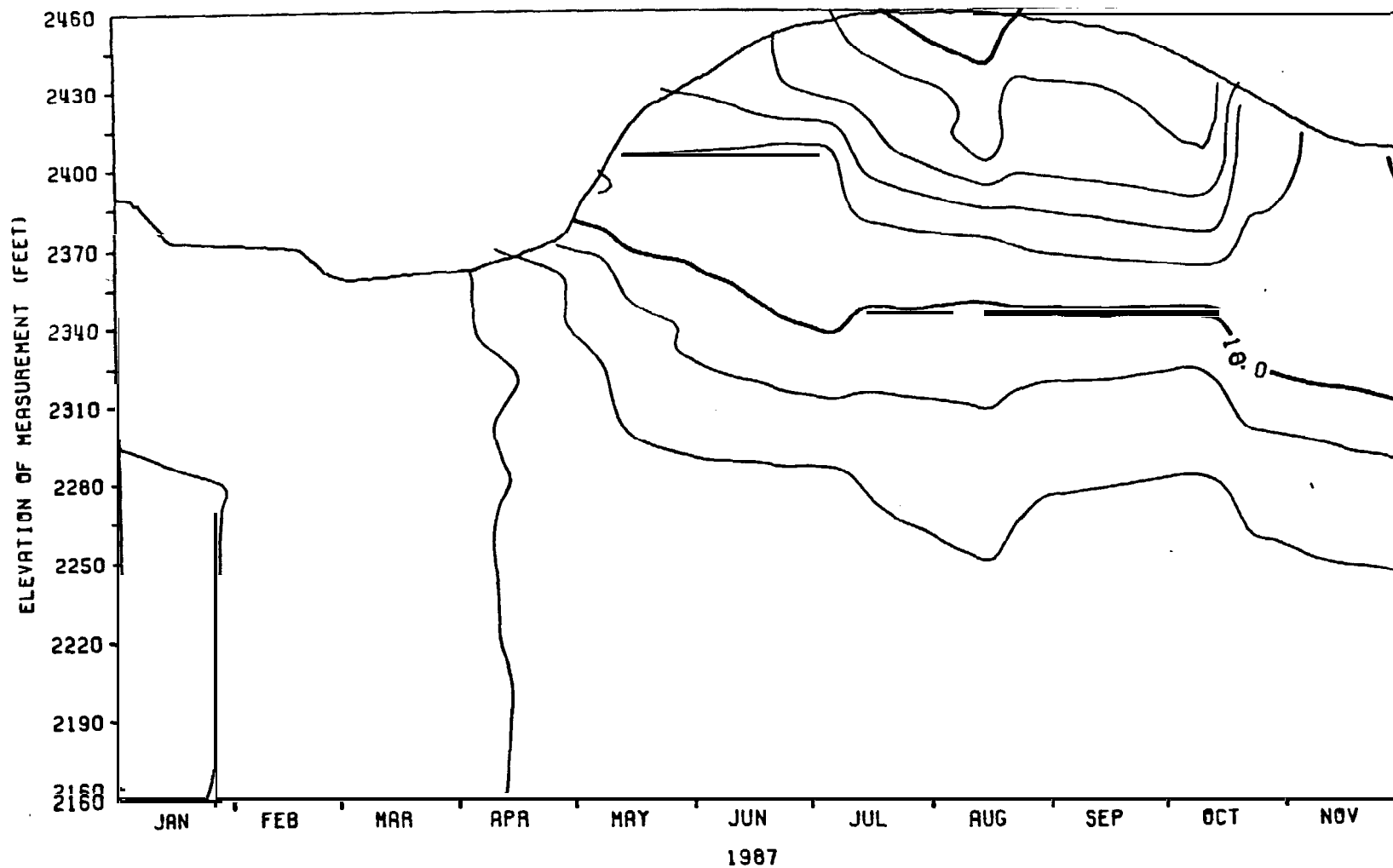


Figure B7. Water temperature profiles (2°C) at reservoir elevations in the Tenmile area of Libby Reservoir, 1987.

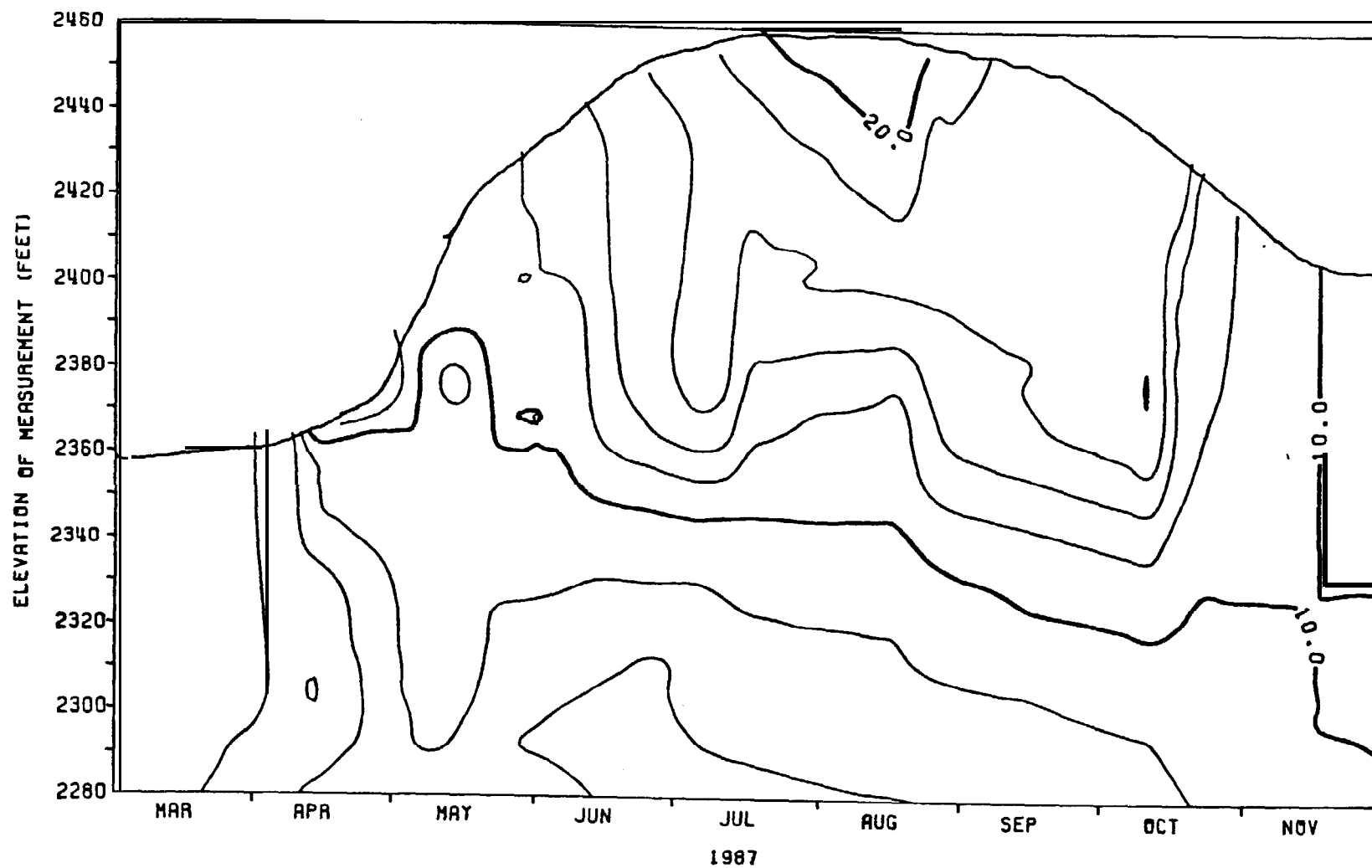


Figure B8. Water temperature profiles ( $^{\circ}\text{C}$ ) at reservoir elevations in the Rexford area of Libby Reservoir, 1987.

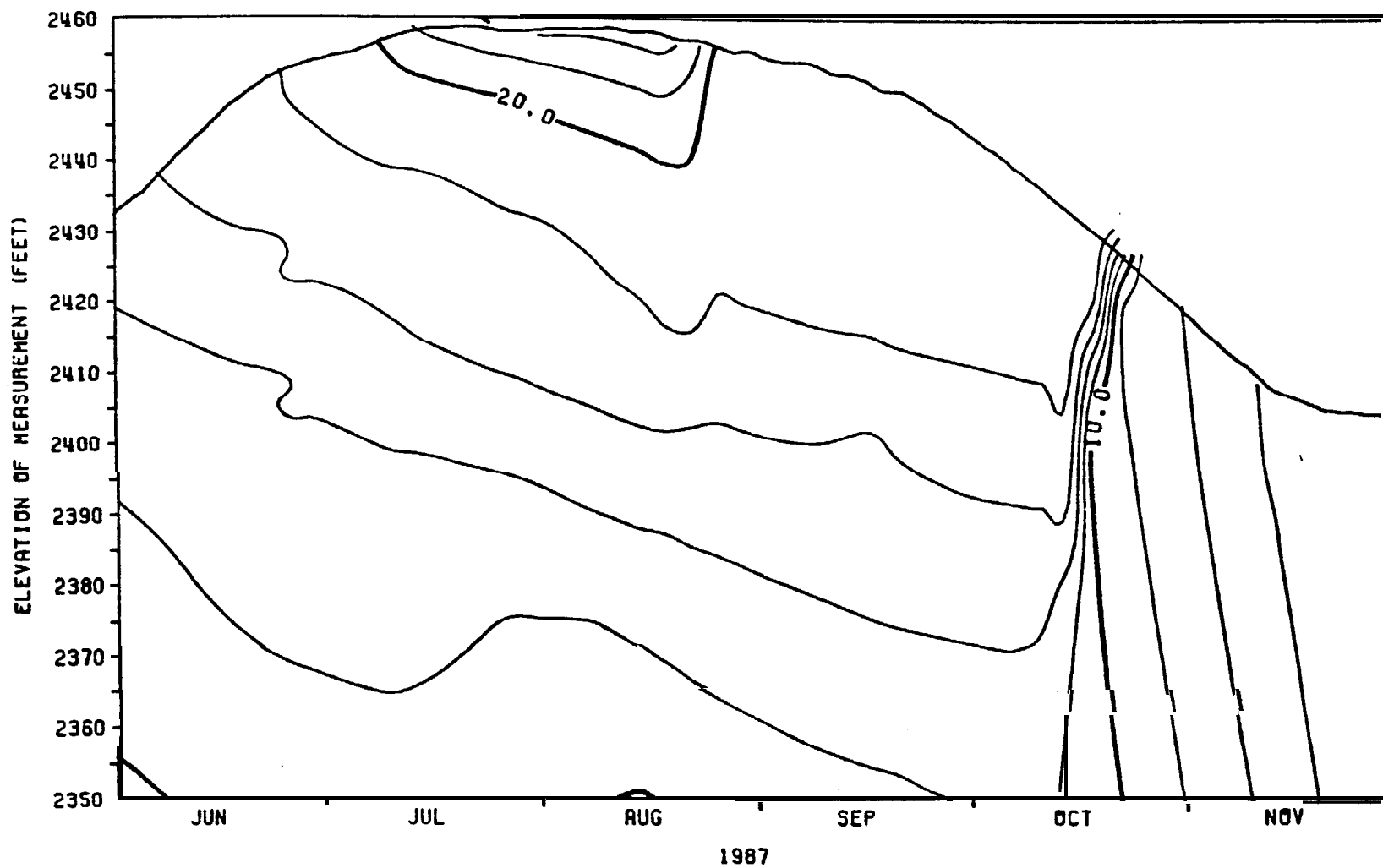


Figure B9. Water temperature profiles ( $2^{\circ}\text{C}$ ) at reservoir elevations in the Tenmile area of Libby Reservoir, 1987.

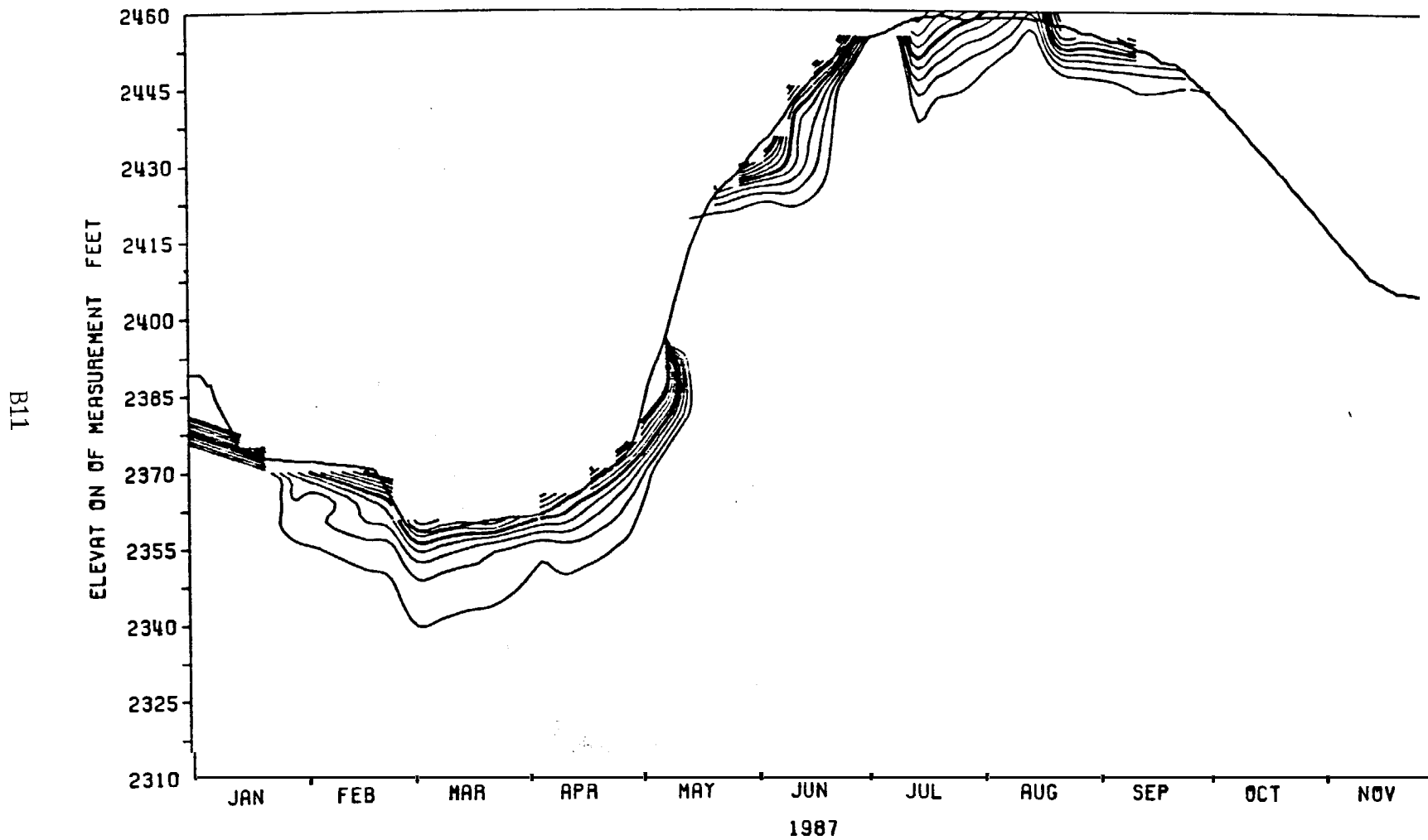


Figure B10. Profiles of light extinction for elevation in the Tenmile area of Libby Reservoir, 1987. Each line represents 10 percent extinction.

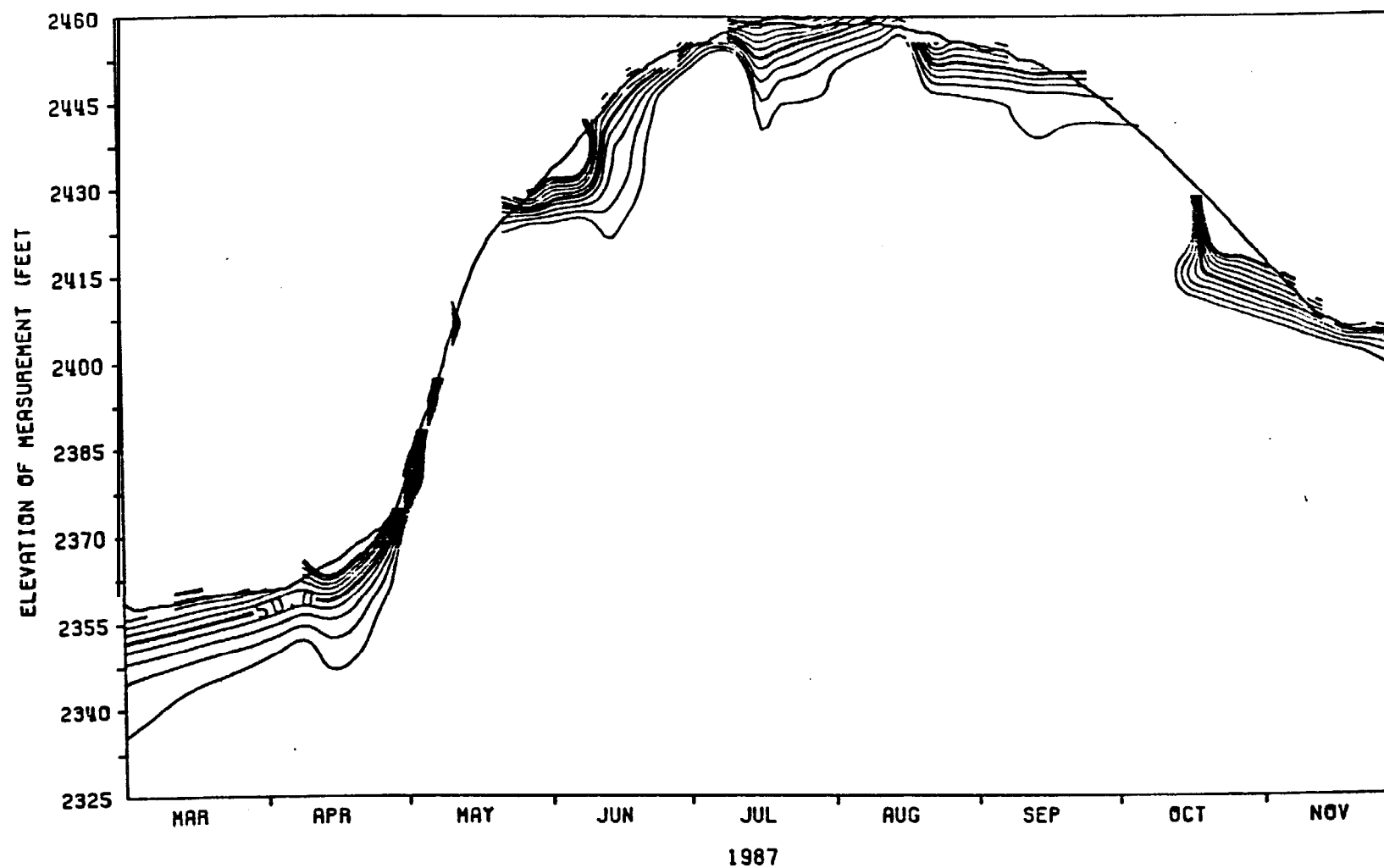


Figure B11. Profiles of light extinction for reservoir elevations in the Rexford area of Libby Reservoir, 1987. Each line represent 10 percent extinction.

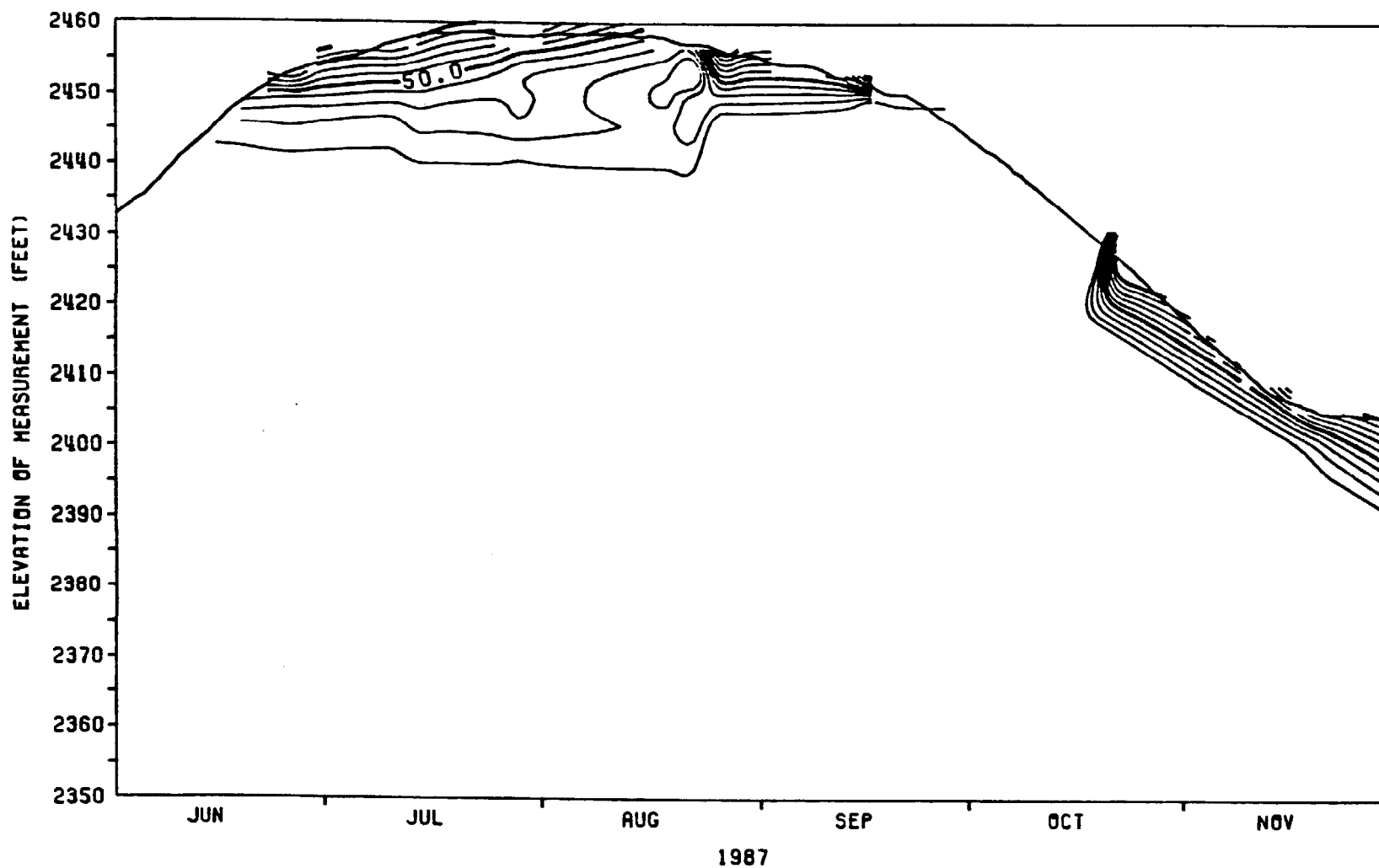


Figure B12. Profiles of light extinction for reservoir elevations in the Canada area of Libby Reservoir, 1987. Each line represents 10 percent extinction.

APPENDIX C  
Tables C1 through C36

Monthly densities and biomasses of terrestrial and  
aquatic invertebrates in the three study areas of  
Libby Reservoir, 1983 through 1987.

Table Cl. Surface invertebrate density in no./ha. (standard deviation) by Order, in the Termile area of Libby Reservoir during 1983.

Date Sites	Terrestrial <sup>a/</sup>							Aquatic <sup>a/</sup>			N	Grand Total
	Col	Hem	Hom	Hym	Ara	Other	Total	Dip	Other	Total		
Aug.											3	
Near shore	--	--	--	124(41.0)	4(6.9)	--	127(43.6)	--	--	--		127
Limnetic	--	--	8(13.3)	691(831.3)	4(6.9)	4(6.9)	707(858.5)	4(6.9)	--	4(6.9)		711
Sept.											4	
Near shore	14(29.0)	--	18(35.0)	--	18(20.3)	9(11.1)	58(93.6)	20(27.4)	--	20(27.4)		78
Limnetic	--	--	9(11.1)	3(6.0)	3(6.0)	18(22.5)	32(35.7)	23(19.2)	--	23(19.2)		55
Oct.											4	
Near shore	3(6.0)	--	6(11.5)	3(6.0)	3(6.0)	3(6.0)	17(11.5)	6(6.9)	--	6(6.9)		23
Limnetic	6(11.5)	3(6.0)	3(6.0)	3(6.0)	3(6.0)	3(6.0)	20(20.0)	9(11.1)	--	9(11.1)		29
Nov.											2	
Near shore	--	6(8.5)	--	6(8.5)	6(8.5)	--	18(7.8)	18(7.8)	--	18(7.8)		35
Limnetic	--	18(7.8)	--	--	6(8.5)	--	23(0.0)	12(0.0)	--	12(0.0)		35
Dec.											2	
Near shore	--	--	--			--	--	--	--	--		--
Limnetic	--	--	--			--	--	--	--	--		--

<sup>a/</sup> Col = Coleoptera; Hem = Hemiptera; Hom = Homoptera; Hym = Hymenoptera; Ara = Arachnida; Dip = Diptera.

Table C2. Surface invertebrate density in no./ha (standard deviation) by Order, in the Temile area of Libby Reservoir during 1984.

Date Sites	Terrestrial <sup>a/</sup>							Aquatic <sup>a/</sup>			N	Grand Total
	Col	Hem	Hom	Hym	Ara	Other	Total	Dip	Other	Total		
Jan.											3	
Near shore	--	--	--	--	--	--	--	--	--	--		--
Limnetic	--	--	--	--	--	--	--	--	--	--		--
Mar.											2	
Near shore	--	--	--	--	--	--	--	--	--	--		--
Limnetic	--	--	--	--	--	--	--	--	--	--		--
Apr.											4	
Near shore	--	--	3(6.0)	6(6.9)	3(6.0)	--	12(9.4)	93(155.3)	--	93(155.3)		105
Limnetic	6(11.5)	--	3(6.0)	6(11.5)	3(6.0)	--	18(22.5)	288(544.9)	--	288(544.9)		305
May											4	
Near shore	35(41.3)	3(6.0)	9(11.1)	70(81.1)	3(6.0)	3(6.0)	122(143.9)	166(192.4)	12(23.5)	177(215.8)		299
Limnetic	20(33.5)	3(6.0)	--	70(80.8)	6(11.5)	--	99(114.4)	46(47.3)	--	46(47.3)		145
June											6	
Near shore	--	--	--	--	6(9.7)	--	6(9.7)	4(6.2)	--	4(6.2)		10
Limnetic	--	--	2(4.9)	2(4.9)	2(4.9)	--	6(6.6)	33(39.4)	--	33(39.4)		39
July											9	
Near shore	17(18.6)	1(4.0)	14(19.9)	16(21.7)	10(18.0)	--	58(60.4)	14(19.3)	1(4.0)	16(18.6)		74
Limnetic	3(5.3)	5(6.3)	12(16.5)	12(15.5)	4(6.0)	1(4.0)	36(27.5)	18(30.2)	--	18(30.2)		55
Aug.											6	
Near shore	12(14.7)	17(32.5)	16(17.6)	418(483.3)	2(4.9)	29(45.1)	494(501.8)	86(92.6)	4(6.2)	89(97.8)		584
Limnetic	6(14.3)	--	8(9.5)	120(113.9)	2(4.9)	14(17.2)	149(128.3)	23(45.8)	8(11.9)	31(54.0)		180
Sept.											3	
Near shore	4(6.9)	--	--	4(6.9)	--	--	8(13.3)	23(11.5)	8(13.3)	31(17.8)		39
Limnetic	--	4(6.9)	4(6.9)	--	--	--	8(6.9)	4(6.9)	--	4(6.9)		12
Oct.											3	
Near shore	109(138.2)	241(87.2)	985(221.7)	372(184.6)	31(17.8)	35(35.0)	1771(200.1)	93(64.8)	23(11.5)	116(72.9)		1888
Limnetic	51(77.6)	213(299.3)	574(588.8)	116(117.7)	20(13.3)	4(6.9)	977(980.4)	54(75.1)	23(20.2)	77(88.6)		1054
Nov.											1	
Near shore	--	--	--	--	--	--	--	--	--	--		--
Limnetic	--	--	--	--	--	--	--	--	--	--		--

<sup>a/</sup> Col = Coleoptera; Hem = Hemiptera; Hom = Homoptera; Hym = Hymenoptera; Ara = Arachnida; Dip = Diptera.

Table C3. Surface invertebrate density in no./ha (standard deviation) by Order, in the Termile area of Libby Reservoir during 1985.

Date Sites	Terrestrial <sup>a/</sup>							Aquatic <sup>a/</sup>			N	Grand Total
	Col	Hem	Hom	Hym	Ara	Other	Total	Dip	Other	Total		
Apr.											2	
Near shore	87(41.0)	--	--	46(48.8)	88(24.7)	--	220(65.8)	308(353.6)	29(8.5)	337(362.0)		558
Limnetic	35(17.0)	--	--	87(41.0)	29(8.5)	--	151(32.5)	657(321.0)	18(7.8)	674(328.8)		826
May											7	
Near shore	168(238.3)	17(23.1)	105(164.3)	106(151.3)	32(59.2)	2(4.5)	428(524.6)	179(123.4)	42(56.4)	221(124.9)		649
Limnetic	77(106.8)	3(8.7)	110(245.2)	110(187.0)	3(8.7)	--	302(445.6)	115(81.7)	3(5.9)	118(79.6)		420
June											6	
Near shore	43(36.5)	10(8.7)	8(11.9)	8(9.5)	24(25.5)	2(4.9)	93(68.7)	10(15.4)	2(4.9)	12(14.7)		105
Limnetic	60(76.0)	12(14.7)	4(6.2)	21(52.3)	25(30.7)	--	122(167.5)	6(9.7)	4(6.2)	10(11.3)		132
July											6	
Near shore	39(67.6)	66(133.2)	15(24.4)	85(85.7)	8(13.4)	--	214(302.3)	64(89.1)	3(6.5)	66(94.3)		280
Limnetic	25(28.3)	20(27.9)	30(31.0)	28(34.5)	--	3(6.5)	106(90.7)	11(16.5)	--	11(16.5)		116
Aug.											6	
Near shore	10(25.7)	24(32.8)	16(10.1)	10164(20919)	3(6.5)	5(13.1)	10222(20973)	442(636.1)	3(6.5)	444(640.5)		10667
Limnetic	5(8.3)	11(19.4)	24(37.1)	6902(12759)	--	--	6942(12814)	26(35.5)	--	26(35.5)		6968
Sept.											6	
Near shore	13(32.3)	56(106.6)	333(755.5)	865(2072)	16(38.8)	3(6.5)	1286(3011)	11(19.4)	10(25.7)	21(27.7)		1307
Limnetic	--	18(32.3)	32(49.1)	79(124.6)	5(13.1)	--	135(210.4)	--	--	--		135
Oct.											3	
Near shore	--	11(18.5)	--	5(9.2)	16(27.7)	5(9.2)	37(39.7)	--	11(9.2)	11(9.2)		48
Limnetic	--	5(9.2)	5(9.2)	5(9.2)	21(18.5)	--	37(32.9)	--	--	--		37
Nov.											2	
Near shore	--	--	--	--	--	--	--	--	--	--		--
Limnetic	--	--	--	--	--	--	--	--	--	--		--

<sup>a/</sup> Col = Coleoptera; Hem = Hemiptera; Hom = Homoptera; Hym = Hymenoptera; Ara = Arachnida; Dip = Diptera.

Table C4. Surface invertebrate density in no./ha (standard deviation) by Order, in the Termile area of Libby Reservoir during 1986.

Date Sites	Terrestrial <sup>a/</sup>							Aquatic <sup>a/</sup>			N	Grand Total
	Col	Hem	Hom	Hym	Ara	Other	Total	Dip	Other	Total		
Apr.											3	
Near shore	53(50.9)	16(0.0)	--	42(39.8)	16(27.7)	--	127(111.1)	32(16.0)	21(36.4)	53(50.9)		180
Limnetic	21(18.5)	5(9.2)	--	5(9.2)	--	--	32(16.0)	5(9.2)	--	5(9.2)		37
May											6	
Near shore	130(163.7)	5(13.1)	3(6.5)	69(95.6)	8(13.4)	--	214(285.0)	299(272.4)	8(8.8)	307(267.5)		521
Limnetic	169(311.5)	21(51.8)	--	40(66.5)	5(13.1)	--	235(437.6)	214(214.9)	3(6.5)	217(220.5)		452
June											6	
Near shore	48(50.2)	--	--	3(6.5)	8(13.4)	--	58(67.6)	3(6.5)	5(13.1)	8(13.4)		66
Limnetic	8(8.8)	--	--	8(8.8)	8(8.8)	5(13.1)	29(25.4)	--	--	--		29
July											6	
Near shore	19(18.7)	3(6.5)	48(78.9)	5(8.3)	--	--	74(83.7)	66(106.0)	--	66(106.0)		140
Limnetic	11(13.1)	--	16(20.2)	11(13.1)	3(6.5)	--	40(27.7)	5(8.3)	3(6.5)	8(8.8)		48
Aug.											6	
Near shore	3(6.5)	3(6.5)	3(6.5)	24(22.1)	--	3(6.5)	34(23.3)	29(48.6)	--	29(48.6)		64
Limnetic	8(19.6)	--	--	48(49.2)	--	--	56(49.9)	5(8.3)	--	5(8.3)		61
Sept.											6	
Near shore	--	--	--	5(8.3)	--	--	5(8.3)	10(25.7)	5(8.3)	16(31.6)		21
Limnetic	--	--	--	3(6.5)	--	--	3(6.5)	5(8.3)	--	5(8.3)		8
Oct.											6	
Near shore	3(6.5)	3(6.5)	19(18.7)	3(6.5)	3(6.5)	--	29(30.7)	16(31.6)	--	16(31.6)		45
Limnetic	--	--	11(16.5)	--	3(6.5)	--	13(15.7)	3(6.5)	--	3(6.5)		16
Nov.											3	
Near shore	--	--	--	--	--	--	--	16(16.0)	--	16(16.0)		16
Limnetic	--	--	--	--	--	--	--	16(27.7)	--	16(27.7)		16
Dec.											2	
Near shore	--	--	--	--	--	--	--	8(11.3)	--	8(11.3)		8
Limnetic	--	--	--	--	--	--	--	--	--	--		--

<sup>a/</sup> Col = Coleoptera; Hem = Hemiptera; Hom = Homoptera; Hym = Hymenoptera; Ara = Arachnida; Dip = Diptera.

Table C5. Surface invertebrate density in no./ha (standard deviation) by Order, in the Termile area of Libby Reservoir during 1987.

Date Sites	Terrestrial <sup>a/</sup>							Aquatic <sup>a/</sup>			N	Grand Total
	Col	Hem	Hom	Hym	Ara	Other	Total	Dip	Other	Total		
Mar.											3	
Near shore	--	--	--	--	5(9.2)	--	5(9.2)	270(217.9)	- -	270(217.9)		275
Limnetic	--	--	--	--	..	..	..	328(568.1)	- -	328(568.1)		328
Apr.											3	
Near shore	212(198.6)	90(78.4)	--	772(171.1)	5(9.2)	--	1079(410.8)	307(352.9)	- -	307(352.9)		1386
Limnetic	259(111.4)	132(112.5)	..	947(653.9)	..	..	1339(869.5)	365(247.7)	11(9.2)	376(243.2)		1714
May											3	
Near shore	--	--	5(9.2)	--	16(0.0)	--	21(9.2)	11(9.2)	11(18.5)	21(24.4)		43
Limnetic	--	--	11(18.5)	--	5(9.2)	..	16(16.0)	11(9.2)	--	11(9.2)		27
June											3	
Near shore	--	--	16(16.0)	--	11(9.2)	--	27(18.5)	5(9.2)	--	5(9.2)		32
Limnetic	--	--	11(9.2)	--	..	..	11(9.2)	..	..	..		11
July											3	
Near shore	259(119.1)	- -	16(27.7)	3122(4888)	5(9.2)	5(9.2)	3407(4975)	206(215.0)	- -	206(215.0)		3614
Limnetic	196(107.8)	11(18.5)	37(50.9)	836(1104)	..	..	1079(1159)	95(165.1)	--	95(165.1)		1175
Sept.											3	
Near shore	--	5(9.2)	32(54.8)	5(9.2)	5(9.2)	5(9.2)	53(78.4)	37(32.9)	--	37(32.9)		90
Limnetic	..	5(9.2)	111(141.3)	11(18.5)	5(9.2)	..	132(165.0)	16(16.0)	5(9.2)	21(24.4)		153

<sup>a/</sup> Col = Coleoptera; Hem = Hemiptera; Hom = Homoptera; Hym = Hymenoptera; Ara = Arachnida; Dip = Diptera.

Table C6. Surface invertebrate density in no./ha (standard deviation) by Order, in the Termile area of Libby Reservoir during 1983-1987.

Date	Terrestrial <sup>a/</sup>							Aquatic <sup>a/</sup>			Grand	
Sites	Col	Hem	Hom	Hym	Ara	Other	Total	Dip	Other	Total	N	Total
Jan. Near shore Limnetic	--	--	--	--	--	--	--	--	--	--	3	--
Mar. Near shore Limnetic	--	--	--	--	3(7.2)	--	3(7.2)	162(213.4) 197(440.1)	--	162(213.4) 197(440.1)	5	165 197
Apr. Near shore Limnetic	81(122.7) 78(120.2)	26(51.3) 34(76.2)	1(3.5) 1(3.5)	213(346.0) 254(503.2)	21(34.9) 6(11.6)	--	342(486.4) 374(691.9)	167(237.7) 298(386.8)	10(20.2) 6(8.6)	177(240.0) 304(390.3)	12	519 677
May Near shore Limnetic	105(172.2) 82(183.3)	8(16.2) 8(28.6)	40(104.6) 40(147.6)	72(109.2) 64(121.9)	16(36.1) 5(10.0)	1(3.7) --	242(367.9) 199(356.3)	187(197.9) 115(143.0)	21(37.3) 2(4.9)	208(200.0) 117(145.4)	20	450 316
June Near shore Limnetic	26(38.6) 19(46.6)	3(6.3) 3(9.1)	4(9.8) 3(6.0)	3(6.6) 9(27.9)	12(17.2) 10(19.1)	1(2.6) 2(7.0)	49(60.2) 46(98.4)	5(9.8) 11(24.9)	2(7.3) 1(3.6)	8(11.3) 12(24.9)	21	56 59
July Near shore Limnetic	53(94.0) 34(72.0)	18(68.5) 8(16.6)	23(43.6) 21(26.7)	419(1780) 119(428.0)	7(13.3) 2(5.0)	1(3.3) 1(4.0)	520(1850) 185(489.0)	64(109.2) 23(59.8)	1(4.0) 1(3.3)	65(109.9) 23(59.6)	24	584 208
Aug. Near shore Limnetic	7(15.9) 5(13.1)	13(25.4) 3(10.9)	10(12.9) 10(21.8)	3048(11435) 2119(7101)	2(4.8) 1(3.6)	11(26.6) 4(10.8)	3090(11464) 2143(7131)	159(372.0) 16(31.1)	2(4.8) 2(6.9)	161(374.6) 19(34.9)	21	3251 2161
Sept. Near shore Limnetic	7(20.4) --	16(57.8) 6(18.0)	98(397.7) 26(62.1)	239(1085) 24(70.3)	8(22.1) 3(7.7)	3(6.8) 3(10.9)	371(1578) 62(130.9)	18(23.6) 8(13.2)	5(14.4) 1(3.4)	23(26.8) 9(14.9)	22	394 72
Oct. Near shore Limnetic	22(66.4) 11(35.0)	48(101.1) 42(138.5)	193(401.2) 113(313.9)	73(163.4) 24(63.2)	11(17.3) 9(13.0)	8(19.0) 2(4.1)	354(707.3) 200(526.3)	25(45.6) 13(34.8)	6(10.8) 4(12.0)	31(53.5) 18(44.4)	16	386 218
Sept. Near shore Limnetic	-- --	2(4.2) 4(8.6)	-- --	2(4.2) --	2(4.2) 2(4.2)	-- --	4(8.6) 6(10.6)	10(12.5) 9(16.7)	-- --	10(12.5) 9(16.7)	8	15 15
Dec. Near shore Limnetic	-- --	-- --	-- --	-- --	-- --	-- --	-- --	4(8.0) --	-- --	4(8.0) --	4	4 --

<sup>a/</sup> Col = Coleoptera; Hem = Hemiptera; Hom = Homoptera; Hym = Hymenoptera; Ara = Arachnida; Dip = Diptera.

Table C7. Surface invertebrate density in no./ha (standard deviation) by Order, in the Rexford area of Libby Reservoir during 1983.

Date Sites	Terrestrial <sup>a/</sup>							Aquatic <sup>a/</sup>			N	Grand Total
	Col	Hem	Hom	Hym	Ara	Other	Total	Dip	Other	Total		
Aug.											2	
Near shore	--	--	--	--	--	--	--	--	--	--		--
Limnetic	--	--	--	19(26.9)	19(26.9)	--	38(54.4)	--	--	--		38
Sept.											3	
Near shore	4(6.9)	--	8(13.3)	4(6.9)	12(11.5)	4(6.9)	31(17.8)	8(13.3)	--	8(13.3)		39
Limnetic	--	--	--	16(6.4)	--	27(26.6)	43(24.4)	12(20.2)	--	12(20.2)		54
Oct.											4	
Near shore	6(6.9)	--	--	--	6(6.9)	--	12(9.4)	6(6.9)	--	6(6.9)		18
Limnetic	12(23.5)	3(6.0)	23(25.0)	3(6.0)	20(20.0)	--	61(70.7)	9(6.0)	6(6.9)	14(11.0)		76
Nov.											1	
Near shore	--	--	12(*****)	--	--	--	12(*****)	23(*****)	--	23(*****)		35
Limnetic	8(6.9)	--	12(20.2)	--	--	4(6.9)	23(11.5)	16(27.1)	--	16(27.1)		39
Dec.											1	
Near shore	--	--	--	--	--	--	--	--	--	--		--
Limnetic	--	--	--	--	--	--	--	--	--	--		--

<sup>a/</sup> Col = Coleoptera; Hem = Hemiptera; Hom = Homoptera; Hym = Hymenoptera; Ara = Arachnida; Dip = Diptera.

Table C8. Surface invertebrate density in no./ha (standard deviation) by Order, in the Rexford area of Libby Reservoir during 1984.

Date Sites	Terrestrial <sup>a/</sup>							Aquatic <sup>a/</sup>			N	Grand Total
	Col	Hem	Hom	Hym	Ara	Other	Total	Dip	Other	Total		
Jan.											2	
Near shore	--	--		--	--	--		--	--	--		--
Limnetic	--	--		--	--	--	--	--	--	--		--
Mar.											4	
Near shore	--	--	14(17.4)	23(46.5)	3(6.0)	9(11.1)	50(63.4)	3(6.0)	--	3(6.0)		53
Limnetic	9(11.1)	--	12(16.5)	20(27.4)	--	12(9.4)	52(39.7)	24(21.4)	--	24(21.4)		76
Apr.											4	
Near shore	6(11.5)	--	--	12(16.5)	9(11.1)	--	26(38.2)	465(461.0)	6(11.5)	471(455.9)		497
Limnetic	--	--	--	3(6.0)	9(11.1)	3(6.0)	15(22.2)	610(875.4)	--	610(875.4)		625
May											4	
Near shore	3(6.0)	--		--	--	--	3(6.0)	250(263.3)	--	250(263.3)		253
Limnetic	3(6.0)	--		3(6.0)	6(11.5)	--	12(13.3)	913(1086)	--	913(1086)		924
June											6	
Near shore	2(4.9)	--	--	4(9.4)	--	--	6(9.7)	16(11.9)	--	16(11.9)		22
Limnetic	--	--	--	2(4.9)	--	--	2(4.9)	4(9.4)	6(9.7)	10(11.3)		12
July											6	
Near shore	33(32.3)	4(6.2)	23(16.5)	18(27.3)	6(6.6)	19(31.6)	103(53.8)	18(12.1)	--	18(12.1)		120
Limnetic	10(11.3)	6(14.3)	6(9.7)	6(6.6)	2(4.9)	6(6.6)	35(37.5)	12(10.3)	--	12(10.3)		47
Aug.											9	
Near shore	3(5.3)	1(4.0)	8(13.0)	57(148.8)	--	1(4.0)	70(161.8)	5(8.5)	--	5(8.5)		75
Limnetic	1(4.0)	--	6(10.2)	8(13.0)	--	1(4.0)	17(24.7)	1(4.0)	--	1(4.0)		18
Sept.											3	
Near shore	--	--	345(567.5)	12(20.2)	--	--	357(587.7)	12(20.2)	--	12(20.2)		368
Limnetic	--	--	58(80.3)	4(6.9)	--	--	62(77.3)	12(11.5)	4(6.9)	15(13.3)		77
Oct.											3	
Near shore	19(33.5)	20(24.4)	353(399.6)	12(11.5)	--	--	403(380.3)	27(24.4)	8(6.9)	35(30.8)		438
Limnetic	8(13.3)	4(6.9)	965(657.1)	31(53.7)	--	4(6.9)	1012(667.9)	43(53.7)	--	43(53.7)		1055

<sup>a/</sup> Col = Coleoptera; Hem = Hemiptera; Hom = Homoptera; Hym = Hymenoptera; Ara = Arachnida; Dip = Diptera.

Table C9. Surface invertebrate density in no./ha (standard deviation) by Order, in the Rexford area of Libby Reservoir during 1985.

Date Sites	Terrestrial <sup>a/</sup>							Aquatic <sup>a/</sup>			N	Grand Total
	Col	Hem	Hom	Hym	Ara	Other	Total	Dip	Other	Total		
Apr.											5	
Near shore	114(217.1)	14(25.1)	--	2(5.4)	28(26.8)	5(10.3)	163(271.3)	916(1617)	2(5.4)	919(1616)		1082
Limnetic	51(66.7)	--	--	--	16(25.4)	--	68(91.0)	593(755.1)	2(5.4)	595(753.1)		663
May											4	
Near shore	12(23.5)	6(11.5)	26(52.5)	29(58.0)	--	--	72(130.1)	76(92.1)	56(59.8)	131(84.4)		204
Limnetic	14(29.0)	--	44(87.0)	15(22.2)	--	--	73(137.6)	128(171.3)	12(23.5)	140(163.1)		212
June											6	
Near shore	29(16.0)	18(12.1)	18(21.6)	31(26.1)	10(11.3)	2(4.9)	106(53.3)	18(20.6)	--	18(20.6)		124
Limnetic	50(60.1)	2(4.9)	21(26.0)	21(22.5)	6(9.7)	--	101(91.8)	20(22.8)	4(6.2)	24(23.2)		124
July											6	
Near shore	34(21.9)	148(238.7)	316(686.0)	42(47.9)	--	--	539(806.0)	44(67.3)	5(13.1)	50(78.2)		589
Limnetic	12(18.3)	55(62.3)	186(175.8)	44(53.4)	3(6.5)	5(7.3)	304(270.5)	16(10.7)	8(19.2)	24(13.2)		328
Aug.											6	
Near shore	--	5(8.3)	29(63.9)	130(254.1)	--	--	164(242.3)	98(231.9)	--	98(231.9)		262
Limnetic	5(8.3)	8(8.8)	11(13.1)	307(728.6)	3(6.5)	3(6.5)	336(745.4)	13(18.7)	--	13(18.7)		349
Sept.											6	
Near shore	8(13.4)	82(149.4)	53(58.2)	29(27.2)	3(6.5)	--	175(195.8)	29(40.5)	3(6.5)	32(38.7)		206
Limnetic	3(6.5)	50(52.6)	116(262.0)	111(241.7)	8(8.8)	--	288(544.6)	26(43.3)	3(6.5)	29(49.6)		318
Oct.											5	
Near shore	--	--	--	--	--	--	--	--	16(27.3)	16(27.3)		16
Limnetic	--	--	--	5(9.2)	--	--	5(9.2)	5(9.2)	5(9.2)	11(18.5)		16

<sup>a/</sup> Col = Coleoptera; Hem = Hemiptera; Hom = Homoptera; Hym = Hymenoptera; Ara = Arachnida; Dip = Diptera.

Table C10. Surface invertebrate density in no./ha (standard deviation) by Order, in the Rexford area of Libby Reservoir during 1986.

Date Sites	Terrestrial <sup>a/</sup>							Aquatic <sup>a/</sup>			N	Grand Total
	Col	Hem	Hom	Hym	Ara	Other	Total	Dip	Other	Total		
Apr.											3	
Near shore	43(9.2)	--	--	79(54.8)	5(9.2)	--	127(55.4)	5(9.2)	5(9.2)	11(18.5)		138
Limnetic	16(16.0)	11(18.5)	--	21(36.4)	--	--	48(47.5)	5(9.2)	--	5(9.2)		53
May											6	
Near shore	64(86.5)	8(13.4)	--	13(25.2)	3(6.5)	--	88(117.5)	492(693.5)	34(84.1)	526(672.7)		614
Limnetic	45(67.0)	5(13.1)	--	3(6.5)	--	--	53(71.5)	466(590.8)	5(13.1)	471(586.0)		524
June											6	
Near shore	32(34.7)	--	8(8.8)	5(8.3)	3(6.5)	3(6.5)	50(38.0)	8(13.4)	--	8(13.4)		58
Limnetic	11(13.1)	5(13.1)	3(6.5)	8(13.4)	3(6.5)	3(6.5)	32(22.3)	3(6.5)	--	3(6.5)		34
July											6	
Near shore	16(14.3)	--	11(19.4)	32(63.6)	3(6.5)	3(6.5)	64(59.5)	3(6.5)	--	3(6.5)		66
Limnetic	5(8.3)	3(6.5)	16(31.6)	40(39.6)	5(13.1)	--	69(63.8)	13(15.7)	--	13(15.7)		82
Aug.											6	
Near shore	11(13.1)	8(13.4)	66(67.7)	278(512.5)	--	--	362(561.8)	5(8.3)	--	5(8.3)		368
Limnetic	3(6.5)	--	19(18.7)	26(57.4)	--	--	48(52.2)	11(13.1)	--	11(13.1)		58
Sept.											3	
Near shore	--	--	16(27.7)	--	--	--	16(27.7)	5(9.2)	--	5(9.2)		21
Limnetic	--	--	16(16.0)	16(27.7)	--	--	32(31.5)	26(45.6)	--	26(45.6)		58
Oct.											9	
Near shore	4(10.7)	18(36.7)	76(82.6)	27(52.1)	2(5.3)	9(11.6)	134(150.5)	138(234.0)	5(16.0)	143(237.5)		277
Limnetic	4(10.7)	32(89.5)	46(66.7)	9(18.1)	2(5.3)	--	92(166.0)	44(60.7)	2(5.3)	46(60.0)		138
Nov.											3	
Near shore	--	--	5(9.2)	--	--	--	5(9.2)	21(9.2)	--	21(9.2)		27
Limnetic	--	--	--	--	--	--	--	11(9.2)	--	11(9.2)		11
Dec.											3	
Near shore	--	--	--	--	--	--	--	--	--	--		--
Limnetic	--	--	--	--	--	--	--	--	--	--		--

<sup>a/</sup> Col = Coleoptera; Hem = Hemiptera; Hom = Homoptera; Hym = Hymenoptera; Ara = Arachnida; Dip = Diptera.

Table C11. Surface invertebrate density in no./ha (standard deviation) by Order, in the Rexford area of Libby Reservoir during 1987.

Date Sites	Terrestrial <sup>a/</sup>							Aquatic <sup>a/</sup>			N	Grand Total
	Col	Hem	Hom	Hym	Ara	Other	Total	Dip	Other	Total		
Mar.											3	
Near shore	--		5(9.2)	--	5(9.2)	11(9.2)	21(24.4)	74(66.1)	5(9.2)	79(69.2)		101
Limnetic	16(27.7)		21(36.4)	5(9.2)	69(60.0)	32(54.8)	143(160.9)	185(39.7)	5(9.2)	190(47.5)		333
Apr.											3	
Near shore	53(36.4)	5(9.2)	5(9.2)	53(8.7)	--		116(37.0)	646(599.5)	21(36.4)	667(634.1)		783
Limnetic	48(47.5)	--	--	21(9.2)	--		69(55.7)	254(207.9)	11(9.2)	265(206.8)		333
May											3	
Near shore	27(24.4)	42(32.7)	42(39.8)	21(24.4)	--	--	132(111.4)	53(8.7)	--	53(8.7)		185
Limnetic	11(9.2)	16(27.7)	21(18.5)	5(9.2)	11(18.5)	--	64(69.2)	42(32.7)	--	42(32.7)		106
June											3	
Near shore	5(9.2)	5(9.2)	5(9.2)	42(32.7)	11(18.5)		69(39.8)	11(18.5)	--	11(18.5)		79
Limnetic	5(9.2)	11(18.5)	--	--	--	--	16(16.0)	11(9.2)	--	11(9.2)		27
July											3	
Near shore	106(117.0)	47(27.1)	106(144.0)	116(103.1)	--		376(381.1)	27(18.5)	--	27(18.5)		403
Limnetic	5(9.2)	21(18.5)	53(48.3)	42(48.3)	--	--	122(119.1)	--	--	--		122
Sept.											3	
Near shore			21(9.2)	--	--	--	21(9.2)	5(9.2)	--	5(9.2)		27
Limnetic			--	--	--	--	--	5(9.2)	--	5(9.2)		5

<sup>a/</sup> Col = Coleoptera; Hem = Hemiptera; Hom = Homoptera; Hym = Hymenoptera; Ara = Arachnida; Dip = Diptera.

Table C12. Surface invertebrate density in no./ha (standard deviation) by Order, in the Rexford area of Libby Reservoir during 1983-1987.

Date Sites	Terrestrial <sup>a/</sup>							Aquatic <sup>a/</sup>			Grand	
	Col	Hem	Hom	Hym	Ara	Other	Total	Dip	Other	Total	N	Total
Jan.											2	
Near shore	--	--	--	--		--	--	--	--	--		--
Limnetic	--	--	--	--		--		--	--	--		--
Mar.											7	
Near shore	--	--	11(14.3)	13(35.2)	4(6.9)	10(9.5)	38(49.4)	33(54.0)	2(6.0)	36(57.3)		73
Limnetic	12(18.2)	--	16(24.5)	14(21.6)	29(50.5)	20(34.1)	91(108.3)	93(90.6)	2(6.0)	95(94.5)		186
Apr.											15	
Near shore	59(125.1)	6(15.3)	1(4.1)	30(38.8)	13(19.4)	2(5.9)	110(158.3)	560(979.2)	8(17.0)	567(981.3)		677
Limnetic	30(46.5)	2(8.3)	--	9(17.6)	8(16.2)	1(3.1)	50(61.5)	412(630.1)	3(6.1)	415(629.1)		465
May											17	
Near shore	31(56.7)	12(21.0)	14(32.0)	15(31.9)	1(3.9)	--	72(104.9)	260(449.0)	25(58.5)	285(440.4)		357
Limnetic	22(43.6)	5(13.6)	14(42.6)	6(12.2)	3(9.3)	--	50(79.5)	417(667.3)	5(13.4)	421(664.5)		471
June											21	
Near shore	19(23.9)	6(10.3)	8(13.9)	18(23.8)	5(9.9)	1(4.3)	56(53.0)	13(15.4)	--	13(15.4)		70
Limnetic	18(37.5)	4(9.8)	7(16.4)	9(15.8)	2(6.3)	1(3.5)	41(62.5)	9(15.0)	3(6.3)	12(15.9)		53
July											21	
Near shore	39(51.4)	50(136.2)	115(371.2)	43(62.3)	2(5.3)	6(18.2)	255(472.1)	22(38.5)	2(7.0)	24(44.2)		279
Limnetic	9(12.3)	21(39.8)	67(120.1)	32(40.3)	3(7.9)	3(5.6)	134(184.3)	12(12.1)	2(10.3)	14(14.0)		148
Aug.											23	
Near shore	4(8.2)	4(8.4)	28(51.7)	129(303.5)	--	1(2.5)	165(333.8)	29(118.4)	--	29(118.4)		194
Limnetic	3(5.9)	2(5.5)	10(13.8)	92(372.4)	2(8.5)	1(4.1)	110(382.4)	7(12.5)	--	7(12.5)		117
Sept.											18	
Near shore	3(8.5)	27(90.2)	83(232.2)	12(20.9)	3(6.8)	1(2.8)	129(260.6)	15(26.2)	1(3.8)	16(25.9)		145
Limnetic	1(3.8)	17(37.5)	51(153.7)	43(140.6)	3(6.1)	5(13.9)	119(322.0)	18(30.8)	2(4.6)	20(33.7)		138
Oct.											21	
Near shore	5(14.2)	10(26.2)	83(180.9)	13(35.5)	2(4.8)	4(8.6)	117(203.9)	64(162.2)	7(16.9)	71(164.1)		188
Limnetic	5(13.4)	16(61.6)	179(415.4)	11(23.9)	5(12.1)	1(2.8)	217(434.3)	30(47.9)	3(5.9)	33(47.3)		250
Nov.											4	
Near shore	--	--	7(8.2)	--	--	--	7(8.2)	22(7.6)	--	22(7.6)		29
Limnetic	4(6.2)	--	6(14.3)	--	--	2(4.9)	12(14.7)	13(18.3)	--	13(18.3)		25
Dec.											4	
Near shore	--	--	--	--	--	--	--	--	--	--		--
Limnetic	--	--	--	--	--	--	--	--	--	--		--

<sup>a/</sup> Col = Coleoptera; Hem = Hemiptera; Hom = Homoptera; Hym = Hymenoptera; Ara = Arachnida; Dip = Diptera.

Table C13. Surface invertebrate density in no./ha (standard deviation) by Order, in the Canada area of Libby Reservoir during 1983.

Date Sites	Terrestrial &							Aquatic <sup>a/</sup>			N	Grand Total
	Col	Hem	Hom	Hym	Ara	Other	Total	Dip	Other	Total		
Sept.											3	
Near shore	20(24.4)	--	4(6.9)	4(6.9)	--	--	27(37.4)	50(57.1)	--	50(57.1)		78
Limnetic	9(17.5)	--	9(11.1)	--	--	9(11.1)	26(25.7)	29(30.8)	3(6.0)	32(27.4)		58
Oct.											3	
Near shore	12(11.5)	12(20.2)	23(40.4)	4(6.9)	--	--	51(67.0)	20(24.4)	--	20(24.4)		70
Limnetic	4(6.9)	16(27.1)	19(33.5)	12(20.2)	--	--	50(87.2)	4(6.9)	--	4(6.9)		54
Nov.											2	
Near shore	18(24.7)	12(16.3)	721(1003)	29(41.0)	6(8.5)	6(8.5)	791(1102)	140(197.3)	6(8.5)	146(205.8)		936
Limnetic	--	6(8.5)	--	--	--	--	6(8.5)	--	--	--		6

<sup>a/</sup> Col = Coleoptera; Hem = Hemiptera; Hom = Homoptera; Hym = Hymenoptera; Ara = Arachnida; Dip = Diptera.

Table C14. Surface invertebrate density in no./ha (standard deviation) by Order, in the Canada area of Libby Reservoir during 1984.

Date Sites	Terrestrial <sup>a/</sup>							Aquatic <sup>a/</sup>			N	Grand Total
	Col	Hem	Hom	Hym	Ara	Other	Total	Dip	Other	Total		
July											6	
Near shore	6(6.6)	4(9.4)	14(13.6)	4(6.2)	6(6.6)	--	33(26.9)	8(9.5)	10(18.8)	18(26.3)		51
Limnetic	8(9.5)	4(9.4)	10(18.8)	4(9.4)	--	4(9.4)	29(25.3)	8(11.9)	4 (6.2)	12(10.3)		41
Aug.											9	
Near shore	13(21.3)	8(11.7)	11(14.9)	41(53.4)	1(4.0)	3(5.3)	76(64.1)	56(43.4)	1 (4.0)	57(42.2)		133
Limnetic	1(4.0)	4(6.0)	9(7.8)	69(167.3)	1(4.0)	--	84(165.7)	30(30.4)	3 (7.7)	32(32.8)		116
Sept.											3	
Near shore	--	--	54(66.2)	--	--	--	54(66.2)	--	--	--		54
Limnetic	--	--	82(120.7)	--	--	--	82(120.7)	19(6.4)	--	19(6.4)		101
Oct.											6	
Near shore	12(23.2)	18(19.2)	70(85.6)	39(63.9)	4(6.2)	4(6.2)	146(167.5)	22(27.0)	--	22(27.0)		167
Limnetic	4(9.4)	10(13.7)	101(137.5)	8(14.1)	2(4.9)	--	124(160.4)	6(9.7)	4(6.2)	10(15.4)		134
Nov.											2	
Near shore	--	--	--	--	--	--	--	--	6(8.5)	6(8.5)		6
Limnetic	--	--	--	--	--	--	--	--	--	--		--

<sup>a/</sup> Col = Coleoptera; Hem = Hemiptera; Hom = Homoptera; Hym = Hymenoptera; Ara = Arachnida; Dip = Diptera.

Table 15. Surface invertebrate density in no./ha (standard deviation) by Order, in the Canada area of Libby Reservoir during 1985.

Date Sites	Terrestrial <sup>a/</sup>							Aquatic <sup>a/</sup>			N	Grand Total
	Col	Hem	Hom	Hym	Ara	Other	Total	Dip	Other	Total		
June											6	
Rear shore	29(28.2)	33(43.6)	4(6.2)	8(9.5)	2(4.9)	--	76(55.6)	12(18.2)	66(48.5)	78(58.0)		153
Limnetic	12(23.2)	16(25.1)	10(23.7)	--	2(4.9)	--	39(33.3)	6(9.9)	8(14.1)	14(17.3)		53
July	3(7.2)	7(15.7)	12(20.8)	9(8.2)	2(5.4)	--	33(33.3)	18(21.1)	--	18(21.1)	5	51
Near shore	14(14.1)	7(15.7)	13(28.2)	13(14.1)	--	--	47(25.7)	24(22.4)	7(6.6)	31(16.3)		78
Limnetic												
Aug.	14(14.4)	18(32.6)	76(111.2)	21(26.0)	2(6.0)	--	131(171.7)	55(45.5)	--	55(45.5)	7	187
Near shore	--	16(28.8)	127(268.7)	5(12.1)	--	--	147(273.0)	93(177.3)	--	93(177.3)		240
Limnetic												
Sept.	5(13.1)	3(6.5)	183(294.6)	27(25.8)	3(6.5)	--	219(304.5)	48(81.4)	3(6.5)	50(87.6)	6	270
Near shore	3(6.5)	8(13.4)	77(93.8)	3(6.5)	--	--	90(93.9)	24(16.8)	--	24(16.8)		114
Limnetic												
Oct.	--	--	3(6.5)	--	--	--	3(6.5)	3(6.5)	--	3(6.5)	6	5
Near shore	--	--	--	3(6.5)	3(6.5)	--	5(8.3)	16(24.4)	5(13.1)	21(37.0)		27
Limnetic												

<sup>a/</sup> Col = Coleoptera; Hem = Hemiptera; Hom = Homoptera; Hym = Hymenoptera; Ara = Arachnida; Dip = Diptera.

Table C16. Surface invertebrate density in no./ha (standard deviation) by Order, in the Canada area of Libby Reservoir during 1986.

Date Sites	Terrestrial <sup>a/</sup>							Aquatic <sup>a/</sup>			N	Grand Total
	Col	Hem	Hom	Hym	Ara	Other	Total	Dip	Other	Total		
June											3	
Near shore	74(32.9)	5(9.2)	--	--	--	--	79(42.0)	21(9.2)	32(41.8)	53(50.9)		132
Limnetic	27(18.5)	5(9.2)	--	5(9.2)	--	--	37(9.2)	5(9.2)	16(27.7)	21(24.4)		59
July											6	
Near shore	8(13.4)	--	11(19.4)	21(44.5)	5(8.3)	--	45(79.8)	95(210.1)	--	95(210.1)		140
Limnetic	--	--	21(23.7)	3(6.5)	--	--	24(21.7)	5(13.1)	11(13.1)	16(20.2)		40
Aug.											6	
Near shore	5(8.3)	--	64(155.5)	643(1458)	--	3(6.5)	714(1430)	143(224.4)	- -	143(224.4)		857
Limnetic	--	--	5(8.3)	1675(4001)	--	--	1680(3998)	166(324.8)	- -	166(324.8)		1846
Sept.											6	
Near shore	3(6.5)	--	8(13.4)	--	--	--	11(13.1)	50(107.9)	--	50(107.9)		61
Limnetic	3(6.5)	3(6.5)	13(18.7)	--	--	--	19(23.6)	74(117.1)	--	74(117.1)		93
Oct.											6	
Near shore	--	3(6.5)	3(6.5)	3(6.5)	--	--	8(13.4)	13(15.7)	21(32.5)	34(42.9)		42
Limnetic	3(6.5)	3(6.5)	3(6.5)	--	3(6.5)	--	11(13.1)	16(20.2)	5(8.3)	21(19.4)		32

<sup>a/</sup> Col = Coleoptera; Hem = Hemiptera; Hom = Homoptera; Hym = Hymenoptera; Ara = Arachnida; Dip = Diptera.

Table C17. Surface invertebrate density in no./ha (standard deviation) by Order, in the Canada area of Libby Reservoir during 1987.

Date Sites	Terrestrial <sup>a/</sup>							Aquatic <sup>a/</sup>			N	Grand Total
	Col	Hem	Hom	Hym	Ara	Other	Total	Dip	Other	Total		
June											3	
Near shore	5(9.2)	5(9.2)	5(9.2)	58(60.0)	5(9.2)	--	80(82.6)	--	--	--		80
Limnetic	5(9.2)	--	5(9.2)	16(0.0)	--	--	27(9.2)	--	--	--		27
July											3	
Near shore	32(31.5)	21(36.4)	48(41.8)	757(1269)	5(9.2)	11(18.5)	873(1361)	138(238.4)	--	138(238.4)		1010
Limnetic	--	11(9.2)	16(27.7)	95(110.9)	--	--	122(101.9)	--	--	--		122
Sept.											3	
Near shore	--	--	11(18.5)	--	--	--	11(18.5)	466(495.6)	--	466(495.6)		476
Limnetic	--	--	--	--	--	--	--	153(64.1)	--	153(64.1)		153

<sup>a/</sup> Col = Coleoptera; Hem = Hemiptera; Hom = Homoptera; Hym = Hymenoptera; Ara = Arachnida; Dip = Diptera.

Table C18. Surface invertebrate density in no./ha (standard deviation) by Order, in the Canada area of Libby Reservoir during 1983-1987.

Date Sites	Terrestrial <sup>a/</sup>							Aquatic <sup>a/</sup>			Grand N	Total
	Col	Hem	Hom	Hym	Ara	Other	Total	Dip	Other	Total		
June											12	
Near shore	34(35.3)	19(33.3)	3(6.1)	18(35.8)	2(5.5)	--	78(54.5)	11(15.1)	41(47.0)	52(55.7)		130
Limnetic	14(19.7)	9(18.7)	6(17.0)	5(7.9)	1(3.5)	--	35(23.7)	4(6.5)	8(16.3)	12(17.6)		48
July											20	
Near shore	10(16.3)	6(16.2)	17(24.3)	123(494.7)	5(6.8)	2(7.2)	163(539.2)	56(142.7)	3(10.7)	59(142.3)		222
Limnetic	6(10.1)	4(9.9)	15(22.6)	20(49.5)	--	1(5.1)	46(51.7)	10(16.3)	6(8.8)	16(17.2)		62
Aug.											22	
Near shore	11(16.2)	9(20.2)	46(101.5)	199(765.0)	1(4.2)	2(4.7)	268(758.9)	79(122.0)	1(2.6)	80(121.8)		348
Limnetic	1(2.6)	7(17.2)	46(154.6)	486(2092)	1(2.6)	--	539(2086)	87(194.1)	1(4.9)	88(193.9)		628
Sept.											21	
Near shore	5(12.4)	1(3.5)	64(168.4)	8(17.8)	1(3.5)	--	79(179.8)	102(230.1)	1(3.5)	102(230.5)		181
Limnetic	3(8.5)	3(8.0)	37(69.5)	1(3.4)	--	2(5.4)	46(71.0)	56(77.0)	1(2.6)	56(76.6)		102
Oct.											21	
Near shore	5(13.5)	7(14.1)	25(54.0)	12(36.4)	1(3.6)	1(3.6)	52(107.0)	14(19.3)	6(18.9)	20(29.4)		71
Limnetic	2(6.3)	6(12.8)	32(82.8)	5(10.9)	2(5.3)	--	47(99.7)	11(17.6)	4(8.5)	15(23.5)		63
Nov.											4	
Near shore	9(17.5)	6(11.5)	360(713.0)	14(29.0)	3(6.0)	3(6.0)	396(783.0)	70(139.5)	6(6.9)	76(143.6)		471
Limnetic	--	3(6.0)	--	--	--	--	3(6.0)	--	--			3

<sup>a/</sup> Col = Coleoptera; Hem = Hemiptera; Hom = Homoptera; Hym = Hymenoptera; Ara = Arachnida; Dip = Diptera.

Table C19. Surface invertebrate biomass in g/ha (standard deviation) by Order, in the Termile area of Libby Reservoir during 1983.

Date Sites	Terrestrial <sup>a/</sup>							Aquatic <sup>a/</sup>			N	Grand Total
	Col	Hem	Hom	Hym	Ara	Other	Total	Dip	Other	Total		
Aug.											3	
Near shore	--	--	--	0.39(0.16)	0.12(0.21)	--	0.51(0.33)	--	--	--		0.51
Limnetic	--	--	0.05(0.09)	2.75(1.99)	0.01(0.01)	0.01(0.01)	2.81(2.09)	--	--	--		2.81
Sept.											4	
Near shore	0.21(0.43)	--	0.06(0.12)	--	0.72(1.35)	4.04(8.06)	5.04(9.96)	0.07(0.09)	--	0.07(0.09)		5.10
Limnetic	--	--	0.14(0.19)	0.01(0.03)	0.05(0.10)	0.02(0.04)	0.22(0.23)	0.15(0.23)	--	0.15(0.23)		0.37
Oct.											4	
Near shore	0.03(0.06)	--	--	0.01(0.02)	0.05(0.10)	0.00(0.01)	0.09(0.10)	0.05(0.09)	--	0.05(0.09)		0.14
Limnetic	0.02(0.04)	0.02(0.04)	0.01(0.02)	0.02(0.04)	0.02(0.04)	0.01(0.02)	0.09(0.08)	--	--	--		0.09
Nov.											2	
Near shore	--	0.03(0.04)	--	0.02(0.03)	0.04(0.06)	--	0.09(0.01)	0.02(0.01)	--	0.02(0.01)		0.10
Limnetic	--	0.09(0.03)	--	--	0.04(0.06)	--	0.14(0.04)	0.02(0.01)	--	0.02(0.01)		0.15
Dec.											2	
Near shore	--	--	--	--	--	--	--	--	--	--		--
Limnetic	--	--	--	--	--	--	--	--	--	--		--

<sup>a/</sup> Col = Coleoptera; Hem = Hemiptera; Hom = Homoptera; Hym = Hymenoptera; Ara = Arachnida; Dip = Diptera.

Table C20. Surface invertebrate biomass in g/ha (standard deviation) by Order, in the Tenmile area of Libby Reservoir during 1984.

Date Sites	Terrestrial <sup>a/</sup>							Aquatic <sup>a/</sup>			Grand	
	Col	Hem	Hom	Hym	Ara	Other	Total	Dip	Other	Total	N	Total
Jan.											3	
Near shore	--	--	--	--	--	--	--	--	--	--		--
Limnetic	--	--	--	--	--	--	--	--	--	--		--
Mar.											2	
Near shore	--	--	--	--	--	--	--	--	--	--		--
Limnetic	--	--	--	--	--	--	--	--	--	--		--
Apr.											4	
Near shore	--	--	0.01(0.03)	0.02(0.02)	0.01(0.03)	--	0.05(0.03)	0.20(0.35)	--	0.20(0.35)		0.25
Limnetic	0.04(0.09)	-	0.01(0.02)	0.01(0.02)	0.01(0.01)	--	0.07(0.09)	1.15(2.25)	--	1.15(2.25)		1.22
May											4	
Near shore	0.58(0.71)	0.00(0.01)	0.02(0.02)	0.47(0.55)	0.02(0.04)	2.06(4.12)	3.14(5.11)	0.92(1.16)	0.01(0.03)	0.93(1.18)		4.07
Limnetic	0.07(0.08)	0.02(0.04)	-	0.34(0.44)	0.06(0.12)	-	0.48(0.56)	0.29(0.42)	--	0.29(0.42)		0.77
June											6	
Near shore	--	--	--	--	0.05(0.07)	-	0.05(0.07)	0.00(0.01)	--	0.00(0.01)		0.05
Limnetic	--	--	--	0.01(0.03)	0.01(0.03)	-	0.03(0.04)	0.01(0.01)	--	0.01(0.01)		0.04
July											9	
Near shore	0.61(1.27)	0.01(0.02)	0.02(0.03)	0.35(0.64)	0.09(0.15)	--	1.09(1.97)	0.12(0.33)	0.01(0.02)	0.13(0.33)		1.21
Limnetic	0.06(0.16)	0.01(0.02)	0.02(0.04)	0.19(0.33)	0.02(0.03)	0.01(0.02)	0.30(0.38)	0.07(0.15)	--	0.07(0.15)		0.38
Aug.											6	
Near shore	0.14(0.18)	0.04(0.06)	0.03(0.06)	0.79(0.88)	0.03(0.07)	0.10(0.19)	1.13(1.03)	0.76(1.70)	0.01(0.02)	0.77(1.71)		1.90
Limnetic	0.03(0.07)	-	0.02(0.03)	0.35(0.39)	0.01(0.02)	0.72(1.74)	1.12(1.67)	0.61(1.45)	0.10(0.17)	0.71(1.60)		1.84
Sept.											3	
Near shore	0.04(0.08)	-	--	0.01(0.01)	-	--	0.05(0.09)	0.09(0.03)	0.02(0.04)	0.11(0.01)		0.16
Limnetic	--	0.38(0.65)	0.01(0.02)	-	--	--	0.39(0.64)	0.01(0.01)	--	0.01(0.01)		0.39
Oct.											3	
Near shore	1.01(1.35)	1.03(0.89)	2.14(0.81)	1.19(1.35)	0.20(0.10)	0.32(0.49)	5.88(1.89)	0.25(0.36)	0.08(0.07)	0.33(0.36)		6.21
Limnetic	0.40(0.68)	2.11(2.26)	0.79(0.70)	0.12(0.14)	0.40(0.47)	0.00(0.01)	3.82(2.69)	0.07(0.07)	0.11(0.13)	0.18(0.19)		4.00
Nov.											1	
Near shore	--	--	--	--	--	--	--	--	--	--		--
Limnetic	--	--	--	--	--	--	--	--	--	--		--

<sup>a/</sup> Col = Coleoptera; Hem = Hemiptera; Hom = Homoptera; Hym = Hymenoptera; Ara = Arachnida; Dip = Diptera.

Table C21. Surface invertebrate biomass in g/ha (standard deviation) by Order, in the Tenmile area of Libby Reservoir during 1985.

Date Sites	Terrestrial <sup>a/</sup>							Aquatic <sup>a/</sup>			N	Grand Total
	Col	Hem	Hom	Hym	Ara	Other	Total	Dip	Other	Total		
Apr.											2	
Near shore	1.35(0.31)	-	-	--	1.82(2.52)	0.55(0.08)	-	3.72(2.91)	0.89(1.23)	0.13(0.07)	1.02(1.16)	4.74
Limnetic	0.65(0.45)	-	-	--	0.44(0.41)	0.15(0.06)	-	1.25(0.04)	1.06(0.18)	0.04(0.01)	1.11(0.16)	2.35
May											7	
Near shore	3.55(5.27)	0.06(0.09)	0.06(0.07)	2.38(5.35)	0.28(0.56)	0.01(0.03)	6.34(11.01)	0.41(0.40)	0.22(0.21)	0.63(0.32)		6.97
Limnetic	1.57(2.99)	0.12(0.32)	0.09(0.19)	2.39(5.86)	0.02(0.05)	--	4.18(9.16)	0.22(0.39)	0.09(0.23)	0.30(0.42)		4.49
June											6	
Near shore	1.47(1.65)	0.03(0.04)	0.01(0.01)	0.07(0.09)	0.18(0.22)	0.03(0.07)	1.80(1.78)	0.01(0.02)	0.02(0.05)	0.03(0.05)		1.83
Limnetic	1.46(2.37)	0.17(0.39)	0.00(0.01)	0.03(0.09)	0.24(0.35)	--	1.91(2.79)	0.00(0.01)	0.00(0.01)	0.01(0.02)		1.92
July											6	
Near shore	0.40(0.66)	0.90(2.10)	0.77(1.78)	0.59(0.81)	0.02(0.04)	--	2.68(2.61)	0.07(0.14)	0.20(0.49)	0.27(0.64)		2.96
Limnetic	0.45(0.48)	0.25(0.38)	0.02(0.04)	0.06(0.06)	--	0.00(0.00)	0.78(0.68)	0.02(0.03)	-	0.02(0.03)		0.80
Aug.											6	
Near shore	1.20(2.93)	0.07(0.12)	0.02(0.05)	14.97(28.19)	0.03(0.09)	0.01(0.03)	16.31(31.28)	0.53(0.97)	0.00(0.01)	0.53(0.98)		16.04
Limnetic	0.05(0.09)	0.01(0.03)	0.09(0.22)	13.70(26.49)	--	--	13.85(26.75)	0.03(0.06)	--	0.03(0.06)		13.88
Sept.											6	
Near shore	0.06(0.14)	0.05(0.07)	0.47(0.83)	2.78(6.76)	0.07(0.18)	0.00(0.00)	3.43(7.33)	0.01(0.01)	0.06(0.16)	0.07(0.15)		3.50
Limnetic	--	0.03(0.07)	0.03(0.05)	0.45(1.03)	0.04(0.09)	--	0.54(1.13)	--	--	--		0.54
Oct.											3	
Near shore	--	0.04(0.07)	-	--	0.11(0.19)	0.01(0.01)	0.16(0.25)	--	0.03(0.03)	0.03(0.03)		0.19
Limnetic	--	0.01(0.02)	0.00(0.01)	0.05(0.08)	0.12(0.11)	--	0.19(0.18)	--	--	--		0.19
Nov.											2	
Near shore	--	--	--	--	--	--	--	--	--	--		--
Limnetic	--	--	--	--	--	--	--	--	--	--		--

<sup>a/</sup> Col = Coleoptera; Hem = Hemiptera; Hom = Homoptera; Hym = Hymenoptera; Ara = Arachnida; Dip = Diptera.

Table C22. Surface invertebrate biomass in g/ha (standard deviation) by Order, in the Termile area of Libby Reservoir during 1986.

Date Sites	Terrestrial <sup>a/</sup>							Aquatic <sup>a/</sup>			N	Grand Total
	Col	Hem	Hom	Hym	Ara	Other	Total	Dip	Other	Total		
Apr.											3	
Near shore	0.59(0.55)	0.05(0.06)	- -	0.17(0.24)	0.25(0.43)	- -	1.04(1.23)	0.02(0.01)	0.05(0.09)	0.07(0.10)		1.11
Limnetic	0.22(0.28)	0.00(0.01)	- -	0.02(0.03)	- -	--	0.24(0.25)	--	--	--		0.24
May											6	
Near shore	1.79(2.19)	0.05(0.11)	0.00(0.00)	0.75(0.99)	0.01(0.01)	--	2.59(3.25)	0.43(0.53)	0.15(0.24)	0.58(0.48)		3.17
Limnetic	3.46(6.02)	0.03(0.07)	- -	0.36(0.57)	0.18(0.43)	--	4.03(6.99)	0.26(0.27)	0.01(0.01)	0.27(0.28)		4.29
June											6	
Near shore	1.50(1.37)	- -	--	0.02(0.04)	0.12(0.20)	- -	1.63(1.49)	0.05(0.13)	0.04(0.09)	0.09(0.14)		1.72
Limnetic	0.15(0.19)	- -	--	0.07(0.09)	0.06(0.08)	0.01(0.04)	0.29(0.24)	--	--	--		0.29
July											6	
Near shore	1.19(1.63)	0.00(0.01)	0.04(0.04)	0.09(0.19)	--	--	1.31(1.55)	0.18(0.25)	- -	0.18(0.25)		1.49
Limnetic	0.10(0.12)	- -	0.01(0.02)	0.20(0.33)	--	--	0.31(0.28)	0.01(0.02)	0.00(0.00)	0.01(0.02)		0.33
Aug.											6	
Near shore	0.00(0.01)	0.01(0.02)	- -	0.03(0.03)	--	0.01(0.01)	0.04(0.04)	0.02(0.02)	- -	0.02(0.02)		0.06
Limnetic	0.04(0.10)	- -	--	0.10(0.17)	- -	--	0.14(0.19)	0.01(0.02)	- -	0.01(0.02)		0.14
Sept.											6	
Near shore	--	--	--	0.00(0.00)	--	--	0.00(0.00)	0.00(0.00)	0.01(0.01)	0.01(0.01)		0.01
Limnetic	--	--	--	0.01(0.01)	--	--	0.01(0.01)	0.00(0.00)	- -	0.00(0.00)		0.01
Oct.											6	
Near shore	0.02(0.04)	0.01(0.02)	0.01(0.01)	0.02(0.04)	0.01(0.02)	--	0.06(0.08)	0.01(0.02)	- -	0.01(0.02)		0.07
Limnetic	--	--	0.00(0.01)	- -	0.00(0.00)	- -	0.01(0.01)	0.00(0.00)	- -	0.00(0.00)		0.01
Nov.											3	
Near shore	--	--	--	--	--	--	--	0.01(0.01)	- -	0.01(0.01)		0.01
Limnetic	--	--	--	--	--	--	--	0.01(0.02)	- -	0.01(0.02)		0.01
Dec.											2	
Near shore	--	--	--	--	--	--	--	--	--	--		--
Limnetic	--	--	--	--	--	--	--	--	--	--		--

<sup>a/</sup> Col = Coleoptera; Hem = Hemiptera; Hom = Homoptera; Hym = Hymenoptera; Ara = Arachnida; Dip = Diptera.

Table C23. Surface invertebrate biomass in g/ha (standard deviation) by Order, in the Termile area of Libby Reservoir during 1987.

Date Sites	Terrestrial <sup>a/</sup>							Aquatic <sup>a/</sup>			N	Grand Total
	Col	Hem	Hom	Hym	Ara	Other	Total	Dip	Other	Total		
Mar.											3	
Near shore	--	--	--	--	0.02(0.04)	--	0.02(0.04)	0.08(0.10)	--	0.08(0.10)		0.10
Limnetic	--	--	--	--	--	--	--	0.05(0.09)	--	0.05(0.09)		0.05
Apr.											3	
Near shore	2.30(1.78)	0.50(0.57)	--	13.10(1.88)	0.05(0.08)	--	15.95(3.64)	0.19(0.14)	--	0.19(0.14)		16.13
Limnetic	2.67(1.56)	0.82(0.67)	--	15.12(11.42)	--	--	18.61(13.55)	0.25(0.18)	0.00(0.01)	0.25(0.18)		18.86
May											3	
Near shore	--	--	--	--	0.10(0.07)	--	0.10(0.07)	0.04(0.07)	0.01(0.02)	0.06(0.06)		0.16
Limnetic	--	--	0.01(0.02)	--	0.00(0.01)	--	0.01(0.02)	0.00(0.01)	--	0.00(0.01)		0.02
June											3	
Near shore	--	--	0.01(0.01)	--	0.07(0.07)	--	0.08(0.07)	--	--	--		0.08
Limnetic	--	--	0.00(0.01)	--	--	--	0.00(0.01)	--	--	--		0.00
July											3	
Near shore	1.74(1.13)	--	0.05(0.09)	2.68(3.80)	--	2.13(3.68)	6.61(5.22)	0.11(0.15)	--	0.11(0.15)		6.71
Limnetic	0.87(0.86)	0.01(0.02)	0.03(0.04)	0.64(0.85)	--	--	1.54(1.12)	0.01(0.01)	--	0.01(0.01)		1.55
Sept.											3	
Near shore	--	0.00(0.01)	0.01(0.01)	0.00(0.01)	0.00(0.01)	0.60(1.05)	0.62(1.03)	0.00(0.01)	--	0.00(0.01)		0.62
Limnetic	--	--	0.01(0.01)	0.00(0.01)	--	--	0.02(0.02)	0.01(0.01)	0.00(0.01)	0.01(0.01)		0.03

<sup>a/</sup> Col = Coleoptera; Hem = Hemiptera; Hom = Homoptera; Hym = Hymenoptera; Ara = Arachnida; Dip = Diptera.

Table C24. Surface invertebrate biomass in g/ha (standard deviation) by Order, in the Tenmile area of Libby Reservoir during 1983-1987.

Date Sites	Terrestrial <sup>a/</sup>							Aquatic <sup>a/</sup>			N	Grand Total
	Col	Hem	Hom	Hym	Ara	Other	Total	Dip	Other	Total		
Jan.											3	
Near shore	--	--	--	--	--	--	--	--	--	--		--
Limnetic	--	--	--	--	--	--	--	--	--	--		--
Mar.											5	
Near shore	--	--	--	--	0.01(0.03)	--	0.01(0.03)	0.05(0.08)	--	0.05(0.08)		0.06
Limnetic	--	--	--	--	--	--	--	0.03(0.07)	--	0.03(0.07)		0.03
Apr.											12	
Near shore	0.95(1.24)	0.14(0.33)	0.00(0.01)	3.63(5.86)	0.17(0.28)	--	4.88(7.04)	0.27(0.52)	0.03(0.07)	0.30(0.53)		5.18
Limnetic	0.84(1.31)	0.21(0.47)	0.00(0.01)	3.86(8.36)	0.03(0.06)	--	4.94(10.08)	0.62(1.29)	0.01(0.02)	0.63(1.29)		5.57
May											20	
Near shore	1.90(3.47)	0.04(0.08)	0.02(0.05)	1.15(3.20)	0.12(0.34)	0.42(1.84)	3.64(7.09)	0.46(0.64)	0.13(0.19)	0.59(0.62)		4.23
Limnetic	1.60(3.79)	0.05(0.19)	0.03(0.11)	1.01(3.47)	0.07(0.24)	--	2.77(6.55)	0.21(0.32)	0.03(0.13)	0.24(0.34)		3.01
June											21	
Near shore	0.85(1.31)	0.01(0.02)	0.00(0.01)	0.03(0.06)	0.11(0.17)	0.01(0.04)	1.00(1.44)	0.02(0.07)	0.02(0.05)	0.04(0.08)		1.04
Limnetic	0.46(1.36)	0.05(0.21)	0.00(0.00)	0.03(0.07)	0.09(0.20)	0.00(0.02)	0.64(1.63)	0.00(0.01)	0.00(0.00)	0.01(0.01)		0.64
July											24	
Near shore	0.85(1.25)	0.23(1.06)	0.22(0.89)	0.63(1.49)	0.04(0.10)	0.27(1.30)	2.23(3.00)	0.12(0.25)	0.05(0.25)	0.17(0.38)		2.41
Limnetic	0.27(0.45)	0.07(0.21)	0.02(0.03)	0.21(0.39)	0.01(0.02)	0.00(0.01)	0.58(0.68)	0.04(0.09)	0.00(0.00)	0.04(0.09)		0.62
Aug.											21	
Near shore	0.38(1.56)	0.03(0.07)	0.02(0.04)	4.57(15.64)	0.03(0.09)	0.03(0.11)	5.07(17.27)	0.37(1.04)	0.00(0.01)	0.38(1.04)		5.44
Limnetic	0.03(0.08)	0.00(0.01)	0.04(0.12)	4.43(14.59)	0.00(0.01)	0.21(0.93)	4.72(14.69)	0.18(0.78)	0.03(0.10)	0.21(0.86)		4.93
Sept.											22	
Near shore	0.06(0.19)	0.01(0.04)	0.14(0.46)	0.76(3.53)	0.15(0.59)	0.82(3.44)	1.94(5.60)	0.03(0.05)	0.02(0.08)	0.05(0.09)		1.99
Limnetic	--	0.06(0.24)	0.04(0.09)	0.13(0.54)	0.02(0.06)	0.00(0.02)	0.24(0.63)	0.03(0.11)	0.00(0.00)	0.03(0.11)		0.27
Oct.											16	
Near shore	0.20(0.64)	0.20(0.52)	0.40(0.91)	0.23(0.69)	0.07(0.12)	0.06(0.22)	1.18(2.44)	0.06(0.17)	0.02(0.04)	0.08(0.18)		1.26
Limnetic	0.08(0.29)	0.40(1.18)	0.15(0.41)	0.04(0.08)	0.10(0.23)	0.00(0.01)	0.77(1.80)	0.01(0.04)	0.02(0.06)	0.04(0.10)		0.81
Nov.											8	
Near shore	--	0.01(0.02)	--	0.01(0.01)	0.01(0.03)	--	0.02(0.04)	0.01(0.01)	--	0.01(0.01)		0.03
Limnetic	--	0.02(0.04)	--	--	0.01(0.03)	--	0.03(0.06)	0.01(0.02)	--	0.01(0.02)		0.04
Dec.											4	
Near shore	--	--	--	--	--	--	--	--	--	--		--

<sup>a/</sup> Col = Coleoptera; Hem = Hemiptera; Hom = Homoptera; Hym = Hymenoptera; Ara = Arachnida; Dip = Diptera.

Table C25. Surface invertebrate biomass in g/ha (standard deviation) by Order, in the Rexford area of Libby Reservoir during 1983.

Date	Terrestrial <sup>a/</sup>							Aquatic <sup>a/</sup>			N	Grand Total
	Col	Hem	Hom	Hym	Ara	Other	Total	Dip	Other	Total		
Aug.											2	
Near shore	--	--	--	--	--	--	--	--	--	--		--
Limnetic	--	--	--	0.06(0.08)	0.01(0.01)	--	0.07(0.09)	--	--	--		0.07
Sept.											3	
Near shore	0.25(0.43)	--	0.26(0.46)	0.02(0.03)	0.03(0.03)	0.00(0.01)	0.57(0.84)	0.00(0.01)	--	0.00(0.01)		0.57
Limnetic	--	--	--	0.06(0.03)	--	3.31(5.62)	3.37(5.65)	0.01(0.01)	--	0.01(0.01)		3.37
Oct.											4	
Near shore	0.10(0.20)	--	--	--	0.04(0.05)	--	0.14(0.19)	0.00(0.01)	--	0.00(0.01)		0.14
Limnetic	0.28(0.56)	0.41(0.82)	0.18(0.35)	0.00(0.01)	0.15(0.14)	--	1.03(1.84)	0.07(0.10)	0.04(0.05)	0.10(0.13)		1.14
Nov.											1	
Near shore	--	--	0.01(*****)	--	--	--	0.01(*****)	--	--	--		0.01
Limnetic	0.10(0.09)	--	0.01(0.02)	--	--	0.00(0.01)	0.12(0.07)	0.00(0.01)	--	0.00(0.01)		0.12
Dec.											1	
Near shore	--	--	--	--	--	--	--	--	--	--		--
Limnetic	--	--	--	--	--	--	--	--	--	--		--

<sup>a/</sup> Col = Coleoptera; Hem = Hemiptera; Hom = Homoptera; Hym = Hymenoptera; Ara = Arachnida; Dip = Diptera.

Table C26. Surface invertebrate biomass in g/ha (standard deviation) by Order, in the Rexford area of Libby Reservoir during 1984.

Date Sites	Terrestrial <sup>a/</sup>							Aquatic <sup>a/</sup>			N	Grand Total
	Col	Hem	Hom	Hym	Ara	Other	Total	Dip	Other	Total		
Jan.											2	
Near shore	--	--	--	--	--	--	--	--	--	--		--
Limnetic	--	--	--	--	--	--	--	--	--	--		--
Mar.											4	
Near shore	--	--	0.01(0.01)	0.06(0.12)	0.04(0.07)	0.03(0.03)	0.13(0.18)	0.01(0.01)	- -	0.01(0.01)		0.13
Limnetic	0.06(0.08)	--	0.01(0.01)	0.05(0.08)	- -	0.03(0.02)	0.15(0.14)	0.04(0.03)	- -	0.04(0.03)		0.19
Apr.											4	
Near shore	0.06(0.11)	--	--	0.05(0.07)	0.07(0.08)	- -	0.17(0.25)	1.32(1.57)	0.01(0.02)	1.33(1.57)		1.50
Limnetic	--	--	--	0.01(0.02)	0.07(0.10)	0.02(0.04)	0.10(0.16)	2.11(2.83)	- -	2.11(2.83)		2.21
May											4	
Near shore	0.40(0.80)	--	--	--	--	--	0.40(0.80)	0.37(0.36)	- -	0.37(0.36)		0.77
Limnetic	0.20(0.40)	--	--	0.00(0.01)	0.04(0.09)	- -	0.24(0.38)	3.67(4.83)	- -	3.67(4.83)		3.91
June											6	
Near shore	0.02(0.06)	--	--	0.22(0.54)	- -	--	0.25(0.53)	0.04(0.06)	- -	0.04(0.06)		0.28
Limnetic	--	--	--	--	--	--	--	0.00(0.01)	0.05(0.09)	0.06(0.09)		0.06
July											6	
Near shore	1.05(1.44)	0.01(0.01)	0.09(0.12)	0.15(0.24)	0.06(0.09)	0.01(0.02)	1.36(1.60)	0.18(0.27)	- -	0.18(0.27)		1.54
Limnetic	0.36(0.53)	0.07(0.18)	0.04(0.09)	0.05(0.10)	0.01(0.03)	0.01(0.02)	0.55(0.67)	0.04(0.05)	- -	0.04(0.05)		0.58
Aug.											9	
Near shore	0.02(0.05)	0.00(0.01)	0.04(0.11)	0.16(0.33)	--	0.47(1.40)	0.69(1.40)	0.01(0.01)	- -	0.01(0.01)		0.69
Limnetic	0.02(0.05)	- -	0.15(0.32)	0.11(0.20)	--	0.50(1.50)	0.78(1.78)	0.02(0.07)	- -	0.02(0.07)		0.80
Sept.											3	
Near shore	--	--	0.22(0.37)	0.49(0.84)	- -	--	0.71(1.22)	0.03(0.05)	- -	0.03(0.05)		0.74
Limnetic	--	--	0.02(0.01)	0.01(0.02)	- -	--	0.03(0.02)	0.04(0.05)	- -	0.04(0.05)		0.06
Oct.											3	
Near shore	0.26(0.46)	0.91(1.55)	0.25(0.33)	0.02(0.03)	--	--	1.44(1.88)	0.08(0.12)	0.03(0.02)	0.11(0.13)		1.55
Limnetic	0.01(0.02)	0.01(0.01)	0.64(0.43)	0.01(0.01)	--	0.01(0.01)	0.67(0.43)	0.14(0.20)	- -	0.14(0.20)		0.81

<sup>a/</sup> Col = Coleoptera; Hem = Hemiptera; Hom = Homoptera; Hym = Hymenoptera; Ara = Arachnida; Dip = Diptera.

Table C27. Surface invertebrate biomass in g/ha (standard deviation) by Order, in the Rexford area of Libby Reservoir during 1985.

Date Sites	Terrestrial <sup>a/</sup>							Aquatic <sup>a/</sup>			N	Grand Total
	Col	Hem	Hom	Hym	Ara	Other	Total	Dip	Other	Total		
Apr.											5	
Near shore	1.02(1.76)	0.06(0.10)	--	0.03(0.08)	0.39(0.37)	0.02(0.04)	1.53(2.26)	3.35(6.15)	0.01(0.01)	3.36(6.15)		4.88
Limnetic	0.72(0.71)	- -	--	--	0.14(0.23)	- -	0.86(0.88)	2.01(2.46)	0.05(0.12)	2.07(2.44)		2.93
May											4	
Near shore	0.69(1.38)	0.12(0.25)	1.42(2.83)	0.56(1.11)	--	--	2.78(5.24)	0.09(0.13)	0.35(0.50)	0.45(0.48)		3.23
Limnetic	0.37(0.74)	- -	0.03(0.05)	0.20(0.36)	--	--	0.59(1.14)	0.30(0.52)	0.03(0.07)	0.33(0.50)		0.92
June											6	
Near shore	0.80(0.50)	0.15(0.15)	0.01(0.02)	0.34(0.59)	0.19(0.25)	0.01(0.03)	1.51(1.11)	0.20(0.22)	--	0.20(0.22)		1.71
Limnetic	1.12(1.10)	0.02(0.05)	0.01(0.02)	0.16(0.20)	0.03(0.05)	--	1.35(1.22)	0.01(0.01)	0.01(0.03)	0.02(0.02)		1.38
July											6	
Near shore	0.53(0.60)	0.16(0.19)	0.39(0.57)	0.39(0.41)	--	--	1.47(0.88)	0.36(0.57)	0.00(0.01)	0.36(0.58)		1.84
Limnetic	0.13(0.21)	0.27(0.33)	0.14(0.11)	0.20(0.30)	0.01(0.02)	0.07(0.17)	0.81(0.64)	0.04(0.04)	0.01(0.02)	0.05(0.03)		0.86
Aug.											6	
Near shore	--	0.01(0.01)	0.01(0.02)	0.30(0.48)	--	--	0.32(0.47)	1.01(2.17)	- -	1.01(2.17)		1.32
Limnetic	0.03(0.05)	0.01(0.01)	0.00(0.01)	0.62(1.51)	0.02(0.04)	0.01(0.03)	0.69(1.56)	0.01(0.01)	--	0.01(0.01)		0.70
Sept.											6	
Near shore	0.06(0.10)	0.11(0.19)	0.40(0.58)	0.08(0.12)	0.03(0.07)	--	0.68(0.65)	0.32(0.50)	0.01(0.02)	0.33(0.49)		1.01
Limnetic	0.00(0.01)	0.08(0.10)	0.07(0.12)	0.33(0.73)	0.11(0.19)	--	0.59(0.91)	0.00(0.01)	0.01(0.01)	0.01(0.02)		0.60
Oct.											5	
Near shore	--	--	--	--	--	--	--	--	0.02(0.04)	0.02(0.04)		0.02
Limnetic	--	--	--	0.01(0.02)	- -	--	0.01(0.02)	0.01(0.01)	0.01(0.02)	0.02(0.03)		0.03

<sup>a/</sup> Col = Coleoptera; Hem = Hemiptera; Hom = Homoptera; Hym = Hymenoptera; Ara = Arachnida; Dip = Diptera.

Table C28. Surface invertebrate biomass in g/ha (standard deviation) by Order, in the Rexford area of Libby Reservoir during 1986.

Date Sites	Terrestrial <sup>a/</sup>							Aquatic <sup>a/</sup>			N	Grand Total
	Col	Hem	Hom	Hym	Ara	Other	Total	Dip	Other	Total		
Apr.											2	
Near shore	5.53(9.18)	--	--	5.53(9.21)	0.02(0.03)	--	11.08(18.39)	--	0.55(0.95)	0.55(0.95)		11.63
Limnetic	0.07(0.09)	0.05(0.08)	--	0.05(0.09)	--	--	0.17(0.16)	--	--	--		0.17
May											6	
Near shore	1.23(1.89)	0.44(1.06)	--	0.48(0.74)	0.03(0.07)	--	2.17(3.41)	0.65(0.92)	0.07(0.18)	0.73(0.88)		2.89
Limnetic	0.71(1.09)	0.02(0.04)	--	0.04(0.11)	--	--	0.77(1.10)	0.74(1.03)	0.01(0.02)	0.75(1.02)		1.52
June											6	
Near shore	0.67(0.79)	--	0.03(0.05)	0.06(0.09)	0.02(0.04)	0.04(0.10)	0.81(0.79)	0.06(0.14)	--	0.06(0.14)		0.87
Limnetic	0.18(0.29)	0.07(0.18)	0.00(0.00)	0.10(0.16)	0.02(0.04)	0.07(0.16)	0.44(0.38)	--	--	--		0.44
July											6	
Near shore	3.11(6.35)	--	0.00(0.01)	2.72(6.60)	--	0.71(1.73)	6.54(12.65)	--	--	--		6.54
Limnetic	2.70(6.53)	0.01(0.04)	2.65(6.49)	2.85(6.87)	0.04(0.11)	--	8.26(19.87)	0.04(0.08)	--	0.04(0.08)		8.30
Aug.											6	
Near shore	0.27(0.38)	0.04(0.06)	0.10(0.10)	0.71(1.33)	--	--	1.11(1.46)	0.00(0.00)	--	0.00(0.00)		1.11
Limnetic	0.02(0.04)	--	0.01(0.01)	0.12(0.21)	--	--	0.15(0.20)	0.00(0.01)	--	0.00(0.01)		0.15
Sept.											3	
Near shore	--	--	0.00(0.01)	--	--	--	0.00(0.01)	--	--	--		0.00
Limnetic	--	--	--	0.00(0.01)	--	--	0.00(0.01)	0.05(0.08)	--	0.05(0.08)		0.05
Oct.											9	
Near shore	0.01(0.02)	0.03(0.08)	0.03(0.05)	0.04(0.10)	0.01(0.03)	0.02(0.03)	0.14(0.21)	0.03(0.02)	0.00(0.01)	0.03(0.03)		0.17
Limnetic	0.04(0.11)	0.27(0.78)	0.01(0.02)	0.00(0.00)	0.00(0.01)	--	0.32(0.79)	0.02(0.02)	0.00(0.01)	0.02(0.02)		0.34
Nov.											3	
Near shore	--	--	0.00(0.01)	--	--	--	0.00(0.01)	0.02(0.02)	--	0.02(0.02)		0.02
Limnetic	--	--	--	--	--	--	--	0.01(0.02)	--	0.01(0.02)		0.01
Dec.											3	
Near shore	--	--	--	--	--	--	--	--	--	--		--
Limnetic	--	--	--	--	--	--	--	--	--	--		--

<sup>a/</sup> Col = Coleoptera; Hem = Hemiptera; Hom = Homoptera; Hym = Hymenoptera; Ara = Arachnida; Dip = Diptera.

Table C29. Surface invertebrate biomass in g/ha (standard deviation) by Order, in the Rexford area of Libby Reservoir during 1987.

Date Sites	Terrestrial <sup>a/</sup>							Aquatic <sup>a/</sup>			N	Grand Total
	Col	Hem	Hom	Hym	Ara	Other	Total	Dip	Other	Total		
Mar.											3	
Near shore	--	--	--	--	0.00(0.01)	0.05(0.06)	0.06(0.07)	0.04(0.06)	0.03(0.06)	0.08(0.07)		0.14
Limnetic	0.05(0.09)	-	-	0.01(0.02)	0.01(0.02)	0.32(0.40)	0.11(0.19)	0.51(0.44)	0.20(0.11)	0.01(0.01)	0.21(0.12)	0.72
Apr.											3	
Near shore	0.91(0.93)	0.03(0.05)	0.00(0.01)	0.36(0.28)	--	--	1.30(1.19)	0.90(0.75)	0.10(0.18)	1.00(0.90)		2.30
Limnetic	0.47(0.55)	-	-	0.02(0.01)	-	--	0.49(0.56)	0.25(0.26)	0.33(0.46)	0.59(0.35)		1.08
W											3	
Near shore	0.25(0.30)	0.11(0.08)	0.03(0.03)	0.06(0.06)	--	--	0.44(0.46)	0.02(0.02)	--	0.02(0.02)		0.47
Limnetic	0.18(0.20)	0.04(0.06)	0.01(0.01)	0.58(1.00)	0.02(0.03)	--	0.82(1.08)	0.02(0.01)	--	0.02(0.01)		0.84
June											3	
Near shore	0.04(0.06)	0.03(0.05)	0.00(0.01)	0.29(0.29)	0.09(0.15)	--	0.45(0.35)	0.01(0.02)	--	0.01(0.02)		0.46
Limnetic	0.07(0.12)	0.05(0.09)	-	--	--	--	0.12(0.10)	--	--	--		0.12
July											3	
Near shore	1.80(1.98)	0.09(0.09)	0.17(0.23)	0.06(0.07)	--	--	2.12(2.37)	0.02(0.02)	--	0.02(0.02)		2.14
Limnetic	0.02(0.03)	0.02(0.02)	0.07(0.06)	0.10(0.15)	--	--	0.21(0.21)	--	--	--		0.21
Sept.											3	
Near shore	--	--	--	--	--	--	--	0.00(0.01)	-	0.00(0.01)		0.00
Limnetic	--	--	--	--	--	--	--	0.00(0.01)	--	0.00(0.01)		0.00

<sup>a/</sup> Col = Coleoptera; Hem = Hemiptera; Hom = Homoptera; Hym = Hymenoptera; Ara = Arachnida; Dip = Diptera.

Table C30. Surface invertebrate biomass in g/ha (standard deviation) by Order, in the Rexford area of Libby Reservoir during 1983-1987.

Date	Terrestrial <sup>a/</sup>							Aquatic <sup>a/</sup>			N	Grand Total
Sites	Col	Hem	Hom	Hym	Ara	Other	Total	Dip	Other	Total		
Jan.											2	
Near shore	--	--	--	--	--	--	--	--	--	--		--
Limnetic	--	--	--	--	--	--	--	--	--	--		--
Mar.											7	
Near shore	--	--	0.01(0.01)	0.03(0.09)	0.02(0.05)	0.04(0.04)	0.10(0.14)	0.02(0.04)	0.01(0.04)	0.04(0.06)		0.13
Limnetic	0.06(0.08)	--	0.01(0.02)	0.03(0.06)	0.14(0.29)	0.06(0.12)	0.30(0.33)	0.11(0.11)	0.00(0.01)	0.11(0.12)		0.41
Apr.											15	
Near shore	1.64(4.16)	0.03(0.06)	0.00(0.00)	1.20(4.14)	0.15(0.27)	0.01(0.02)	3.03(8.22)	1.65(3.63)	0.13(0.42)	1.78(3.60)		4.81
Limnetic	0.35(0.54)	0.01(0.04)	--	0.02(0.04)	0.07(0.15)	0.01(0.02)	0.44(0.62)	1.29(2.10)	0.08(0.23)	1.37(2.07)		1.81
May											17	
Near shore	0.73(1.33)	0.20(0.63)	0.34(1.37)	0.31(0.68)	0.01(0.04)	--	1.59(3.16)	0.34(0.60)	0.11(0.28)	0.45(0.61)		2.04
Limnetic	0.42(0.75)	0.01(0.03)	0.01(0.02)	0.16(0.44)	0.01(0.04)	--	0.61(0.92)	1.20(2.61)	0.01(0.03)	1.21(2.61)		1.82
June											21	
Near shore	0.43(0.59)	0.05(0.10)	0.01(0.03)	0.22(0.43)	0.07(0.16)	0.02(0.05)	0.80(0.90)	0.09(0.15)	--	0.09(0.15)		0.88
Limnetic	0.38(0.75)	0.03(0.10)	0.00(0.01)	0.07(0.15)	0.01(0.04)	0.02(0.09)	0.53(0.85)	0.00(0.01)	0.02(0.05)	0.02(0.05)		0.55
July											21	
Near shore	1.60(3.49)	0.06(0.12)	0.16(0.34)	0.94(3.51)	0.02(0.05)	0.20(0.92)	2.98(6.84)	0.16(0.35)	0.00(0.00)	0.16(0.35)		3.14
Limnetic	0.92(3.48)	0.10(0.22)	0.82(3.46)	0.90(3.66)	0.02(0.06)	0.02(0.09)	2.78(10.56)	0.03(0.05)	0.00(0.01)	0.04(0.05)		2.81
Aug.											23	
Near shore	0.08(0.21)	0.01(0.03)	0.04(0.09)	0.33(0.74)	--	0.18(0.88)	0.64(1.17)	0.26(1.13)	--	0.26(1.13)		0.91
Limnetic	0.02(0.04)	0.00(0.01)	0.06(0.20)	0.24(0.77)	0.01(0.02)	0.20(0.94)	0.53(1.35)	0.01(0.04)	--	0.01(0.04)		0.54
Sept.											18	
Near shore	0.06(0.18)	0.04(0.11)	0.22(0.41)	0.11(0.35)	0.02(0.04)	0.00(0.00)	0.44(0.70)	0.11(0.31)	0.00(0.01)	0.12(0.31)		0.56
Limnetic	0.00(0.00)	0.03(0.06)	0.03(0.07)	0.12(0.42)	0.04(0.12)	0.55(2.31)	0.76(2.35)	0.02(0.04)	0.00(0.01)	0.02(0.04)		0.78
Oct.											21	
Near shore	0.06(0.19)	0.14(0.59)	0.05(0.14)	0.02(0.07)	0.01(0.03)	0.01(0.02)	0.29(0.78)	0.02(0.05)	0.01(0.02)	0.03(0.06)		0.32
Limnetic	0.08(0.27)	0.21(0.64)	0.15(0.31)	0.00(0.01)	0.03(0.08)	0.00(0.00)	0.48(0.99)	0.05(0.09)	0.01(0.03)	0.06(0.10)		0.53
Nov.											4	
Near shore	--	--	0.01(0.01)	--	--	--	0.01(0.01)	0.02(0.02)	--	0.02(0.02)		0.02
Limnetic	0.05(0.08)	--	0.01(0.02)	--	--	0.00(0.00)	0.06(0.08)	0.01(0.01)	--	0.01(0.01)		0.07
Dec.											4	
Near shore	--	--	--	--	--	--	--	--	--	--		--
Limnetic	--	--	--	--	--	--	--	--	--	--		--

<sup>a/</sup> Col = Coleoptera; Hem = Hemiptera; Hom = Homoptera; Hym = Hymenoptera; Ara = Arachnida; Dip = Diptera.

Table C31. Surface invertebrate biomass in g/ha (standard deviation) by Order, in the Canada area of Libby Reservoir during 1983.

Date Sites	Terrestrial <sup>a/</sup>							Aquatic <sup>a/</sup>			N	Grand Total
	cot	Hem	Hom	Hym	Ara	Other	Total	Dip	Other	Total		
Sept.											3	
Near shore	0.67(0.74)	--	0.00(0.01)	0.02(0.03)	--	--	0.69(0.78)	0.95(1.57)	--	0.95(1.57)		1.64
Limnetic	0.21(0.41)	--	0.18(0.35)	--	--	0.02(0.02)	0.41(0.76)	0.71(1.39)	0.02(0.04)	0.72(1.38)		1.13
Oct.											3	
Near shore	0.30(0.32)	0.20(0.34)	0.15(0.26)	0.01(0.01)	--	--	0.66(0.89)	0.03(0.04)	--	0.03(0.04)		0.69
Limnetic	0.04(0.06)	0.22(0.38)	0.01(0.01)	0.32(0.55)	--	--	0.58(1.00)	0.01(0.02)	--	0.01(0.02)		0.59
Nov.											2	
Near shore	0.66(0.93)	0.07(0.09)	0.47(0.66)	0.04(0.05)	0.01(0.01)	0.04(0.05)	1.26(1.77)	0.35(0.49)	0.01(0.01)	0.35(0.50)		1.62
Limnetic	--	0.10(0.13)	--	--	--	--	0.10(0.13)	--	--	--		0.10

<sup>a/</sup> Col = Coleoptera; Hem = Hemiptera; Hom = Homoptera; Hym = Hymenoptera; Ara = Arachnida; Dip = Diptera.

Table C32. Surface invertebrate biomass in g/ha (standard deviation) by Order, in the Canada area of Libby Reservoir during 1984.

Date Sites	Terrestrial <sup>a/</sup>							Aquatic <sup>a/</sup>			N	Grand Total
	Col	Hem	Hom	Hym	Ara	Other	Total	Dip	Other	Total		
July											6	
Near shore	0.36(0.48)	0.03(0.08)	0.01(0.01)	0.04(0.09)	0.04(0.07)	--	0.48(0.52)	0.41(0.98)	0.30(0.72)	0.71(1.10)		1.20
Limnetic	0.16(0.31)	0.01(0.02)	0.01(0.01)	0.05(0.13)	--	0.00(0.01)	0.23(0.33)	0.01(0.01)	0.07(0.12)	0.07(0.12)		0.30
Aug.											9	
Near shore	0.22(0.47)	0.12(0.30)	0.04(0.08)	0.14(0.13)	0.29(0.86)	0.00(0.01)	0.80(1.03)	0.47(0.50)	0.00(0.00)	0.47(0.50)		1.28
Limnetic	0.02(0.05)	0.14(0.29)	0.01(0.02)	0.36(0.91)	0.02(0.06)	--	0.55(0.90)	0.17(0.25)	0.03(0.08)	0.20(0.32)		0.75
Sept.											3	
Near shore	--	--	0.02(0.03)	--	--	--	0.02(0.03)	--	--	--		0.02
Limnetic	--	--	0.04(0.06)	-	-	-	0.04(0.06)	0.06(0.04)	-	-	0.06(0.04)	0.09
Oct.											6	
Near shore	0.54(1.16)	0.06(0.09)	0.03(0.06)	0.19(0.31)	0.02(0.03)	0.02(0.06)	0.86(1.42)	0.14(0.23)	--	0.14(0.23)		1.01
Limnetic	0.00(0.01)	0.02(0.03)	0.04(0.05)	0.01(0.01)	0.01(0.01)	--	0.07(0.09)	0.00(0.00)	0.01(0.01)	0.01(0.02)		0.08
Nov.											2	
Near shore	--	--	--	--	--	--	--	--	0.01(0.01)	0.01(0.01)		0.01
Limnetic	--	--	--	--	--	--	--	--	--	--		--

<sup>a/</sup> Col = Coleoptera; Hem = Hemiptera; Hom = Homoptera; Hym = Hymenoptera; Ara = Arachnida; Dip = Diptera.

Table C33. Surface invertebrate biomass in g/ha (standard deviation) by Order, in the Canada area of Libby Reservoir during 1985.

Date Sites	Terrestrial <sup>a/</sup>							Aquatic <sup>a/</sup>			N	Grand Total
	Col	Hem	Hom	Hym	Ara	Other	Total	Dip	Other	Total		
June											6	
Near shore	0.65(0.89)	0.24(0.36)	0.00(0.00)	0.11(0.26)	0.03(0.08)	--	1.03(1.11)	0.08(0.12)	0.92(1.66)	1.00(1.76)		2.04
Limnetic	0.20(0.41)	0.20(0.46)	0.06(0.13)	--	0.01(0.03)	--	0.48(0.53)	0.01(0.01)	0.01(0.02)	0.02(0.03)		0.50
July											5	
Near shore	0.00(0.01)	0.32(0.72)	0.06(0.11)	0.01(0.02)	0.02(0.05)	--	0.43(0.79)	0.01(0.02)	- -	0.01(0.02)		0.44
Limnetic	0.09(0.12)	0.07(0.17)	0.00(0.00)	0.05(0.09)	--	--	0.22(0.21)	0.02(0.02)	0.10(0.19)	0.12(0.18)		0.33
Aug.											7	
Near shore	0.20(0.22)	0.11(0.27)	0.05(0.09)	0.04(0.05)	0.01(0.02)	--	0.41(0.52)	0.09(0.14)	- -	0.09(0.14)		0.50
Limnetic	--	0.02(0.05)	0.02(0.03)	0.00(0.01)	--	--	0.05(0.07)	0.02(0.03)	- -	0.02(0.03)		0.07
Sept.											6	
Near shore	0.04(0.10)	0.01(0.01)	0.35(0.76)	0.13(0.16)	0.01(0.03)	--	0.54(0.70)	0.01(0.02)	0.01(0.01)	0.01(0.03)		0.55
Limnetic	0.14(0.34)	0.03(0.05)	0.10(0.19)	0.01(0.03)	--	--	0.29(0.35)	0.09(0.12)	- -	0.09(0.12)		0.37
Oct.											6	
Near shore	--	--	--	--	--	--	--	--	--	--		--
Limnetic	--	--	--	0.00(0.00)	0.01(0.03)	--	0.01(0.03)	0.06(0.14)	0.01(0.03)	0.07(0.17)		0.09

<sup>a/</sup> Col = Coleoptera; Hem = Hemiptera; Hom = Homoptera; Hym = Hymenoptera; Ara = Arachnida; Dip = Diptera.

Table C34. Surface invertebrate biomass in g/ha (standard deviation) by Order, in the Canada area of Libby Reservoir during 1986.

Date Sites	Terrestrial <sup>a/</sup>							Aquatic <sup>a/</sup>			N	Grand Total
	Col	Hem	Hom	Hym	Ara	Other	Total	Dip	Other	Total		
June											3	
Near shore	2.57(1.10)	0.01(0.01)	- -	--	--	--	2.58(1.12)	0.46(0.76)	0.06(0.10)	0.52(0.71)		3.09
Limnetic	0.68(0.15)	0.28(0.49)	- -	0.00(0.01)	--	--	0.96(0.42)	0.00(0.01)	0.07(0.12)	0.07(0.12)		1.04
July											6	
Near shore	0.03(0.06)	--	0.01(0.01)	0.07(0.15)	0.03(0.07)	--	0.14(0.25)	0.02(0.04)	- -	0.02(0.04)		0.16
Limnetic	--	--	0.01(0.01)	0.04(0.09)	- -	--	0.05(0.09)	0.00(0.00)	0.30(0.73)	0.30(0.73)		0.35
Aug.											6	
Near shore	0.03(0.04)	- -	0.01(0.04)	0.41(0.66)	- -	--	0.45(0.64)	0.03(0.05)	- -	0.03(0.05)		0.47
Limnetic	--	--	0.00(0.00)	1.29(2.61)	--	--	1.29(2.61)	0.07(0.08)	- -	0.07(0.08)		1.36
Sept.											6	
Near shore	0.01(0.03)	- -	0.00(0.00)	--	--	--	0.01(0.03)	0.00(0.01)	- -	0.00(0.01)		0.02
Limnetic	0.02(0.05)	0.01(0.01)	0.01(0.01)	--	--	--	0.03(0.06)	0.01(0.01)	- -	0.01(0.01)		0.04
Oct.											6	
Near shore	--	0.00(0.01)	- -	0.01(0.02)	- -	--	0.01(0.02)	0.00(0.00)	0.13(0.28)	0.13(0.28)		0.15
Limnetic	0.04(0.10)	0.00(0.00)	0.00(0.00)	--	0.01(0.03)	--	0.06(0.11)	0.00(0.00)	0.01(0.02)	0.02(0.02)		0.08

<sup>a/</sup> Col = Coleoptera; Hem = Hemiptera; Hom = Homoptera; Hym = Hymenoptera; Ara = Arachnida; Dip = Diptera.

Table C35. Surface invertebrate biomass in g/ha (standard deviation) by Order, in the Canada area of Libby Reservoir during 1987.

Date Sites	Terrestrial <sup>a/</sup>							Aquatic <sup>a/</sup>			N	Grand Total
	Col	Hem	Hom	Hym	Ara	Other	Total	Dip	Other	Total		
June											3	
Near shore	0.06(0.10)	0.01(0.02)	--	1.14(1.44)	0.02(0.03)	--	1.22(1.55)	--	--	--		1.22
Limnetic	0.90(1.56)	--	--	0.09(0.02)	--	--	0.98(1.56)	--	--	--		0.98
July											3	
Near shore	0.08(0.08)	0.01(0.02)	0.02(0.02)	1.15(1.99)	0.00(0.01)	1.58(2.74)	2.86(2.38)	0.08(0.14)	--	0.08(0.14)		2.95
Limnetic	--	0.00(0.01)	0.05(0.08)	0.29(0.46)	--	--	0.34(0.43)	--	--	--		0.34
Sept.											3	
Near shore	--	--	0.01(0.01)	--	--	--	0.01(0.01)	0.09(0.09)	--	0.09(0.09)		0.09
Limnetic	--	--	--	--	--	--	--	0.05(0.06)	--	0.05(0.06)		0.05

<sup>a/</sup> Col □ Coleoptera; Hem □ Hemiptera; Hom □ Homoptera; Hym = Hymenoptera; Ara = Arachnida; Dip □ Diptera.

Table C36. Surface invertebrate biomass in g/ha (standard deviation) by Order, in the Canada area of Libby Reservoir during 1983-1987.

Date Sites	Terrestrial <sup>a/</sup>							Aquatic <sup>a/</sup>			N	Grand Total
	Col	Hem	Hom	Hym	Ara	Other	Total	Dip	Other	Total		
June											12	
Near shore	0.98(1.25)	0.12(0.27)	0.00(0.00)	0.34(0.80)	0.02(0.06)	--	1.47(1.30)	0.15(0.38)	0.48(1.21)	0.63(1.30)		2.10
Littoral	0.50(0.79)	0.17(0.39)	0.03(0.10)	0.02(0.04)	0.01(0.02)	--	0.73(0.82)	0.00(0.01)	0.02(0.06)	0.03(0.06)		0.75
July											20	
Near shore	0.13(0.29)	0.09(0.36)	0.02(0.06)	0.21(0.77)	0.03(0.06)	0.24(1.06)	0.72(1.30)	0.14(0.54)	0.09(0.40)	0.23(0.65)		0.96
Littoral	0.07(0.18)	0.02(0.08)	0.01(0.03)	0.08(0.20)	--	0.00(0.00)	0.19(0.27)	0.01(0.01)	0.14(0.41)	0.14(0.41)		0.33
Aug.											22	
Near shore	0.16(0.33)	0.09(0.24)	0.04(0.07)	0.18(0.36)	0.12(0.55)	0.00(0.00)	0.58(0.79)	0.23(0.38)	0.00(0.00)	0.23(0.38)		0.81
Littoral	0.01(0.03)	0.07(0.19)	0.01(0.02)	0.50(1.48)	0.01(0.04)	--	0.59(1.47)	0.10(0.17)	0.01(0.05)	0.11(0.22)		0.70
Sept.											21	
Near shore	0.11(0.34)	0.00(0.01)	0.10(0.41)	0.04(0.10)	0.00(0.02)	--	0.26(0.52)	0.15(0.60)	0.00(0.01)	0.15(0.60)		0.41
Littoral	0.08(0.24)	0.01(0.03)	0.07(0.18)	0.00(0.02)	--	0.00(0.01)	0.17(0.37)	0.17(0.59)	0.00(0.01)	0.17(0.59)		0.34
Oct.											21	
Near shore	0.20(0.64)	0.05(0.14)	0.03(0.10)	0.06(0.18)	0.01(0.02)	0.01(0.03)	0.34(0.86)	0.05(0.13)	0.04(0.15)	0.08(0.19)		0.43
Littoral	0.02(0.06)	0.04(0.14)	0.01(0.03)	0.05(0.21)	0.01(0.02)	--	0.12(0.38)	0.02(0.08)	0.01(0.02)	0.03(0.09)		0.15
Nov.											4	
Near shore	0.33(0.66)	0.03(0.07)	0.24(0.47)	0.02(0.04)	0.00(0.01)	0.02(0.04)	0.63(1.26)	0.17(0.35)	0.01(0.01)	0.18(0.35)		0.81
Littoral	--	0.05(0.10)	--	--	--	--	0.05(0.10)	--	--	--		0.05

<sup>a/</sup> Col = Coleoptera; Hem = Hemiptera; Hom = Homoptera; Hym = Hymenoptera; Ara = Arachnida; Dip = Diptera.

APPENDIX D  
Tables D1 through D18

Mean zooplankton densities and variances estimated from 0- to 30-m  
vertical tows made in three areas of Libby Reservoir,  
1983 through 1987.

Table D1. Mean zooplankton densities (no./l) (top line) and variances (bottom line) estimated from 0-30 m vertical tows made in the Tenmile area of Libby Reservoir during 1983.

Month	(N)	Daphnia	Bosmina	Cyclops	Diaptomus	Epischura <sup>a/</sup>	Leptodora <sup>a/</sup>
August	(1)	0.87 *****	0.14 *****	2.86 *****	1.72 *****	0.00 *****	0.00 *****
September	(4)	1.63 0.99	0.31 0.04	4.56 12.07	3.70 14.53	14.13 133.50	0.00 0.00
October	(5)	1.56 0.85	0.01 0.00	2.02 0.92	1.40 0.34	9.88 14.83	0.00 0.00
November	(1)	1.08 *****	0.01 *****	1.78 *****	1.60 *****	7.07 *****	0.00 *****
December	(2)	0.44 0.00	0.00 0.00	1.36 0.00	1.07 0.10	0.00 0.00	0.00 0.00

<sup>a/</sup> Epischura and Leptodora were measured as number per m<sup>3</sup>.

Table D2. Mean zooplankton densities (no./l) (top line) and variances (bottom line) estimated from 0-30 m vertical tows made in the Tenmile area of Libby Reservoir during 1984.

Month	(N)	Daphnia	Bosmina	Cyclops	Diaptomus	Epischura <sup>a/</sup>	Leptodora <sup>a/</sup>
January	(5)	0.55 0.00	0.00 0.00	3.31 1.48	1.16 0.15	19.81 460.40	0.00 0.00
February	(1)	4.57 *****	0.11 *****	5.28 *****	3.02 *****	0.00 *****	0.00 *****
March	(2)	0.28 0.00	0.03 0.00	1.47 0.08	0.97 0.24	3.54 24.99	0.00 0.00
April	(4)	0.44 0.05	0.03 0.00	1.04 0.14	0.75 0.08	0.00 0.00	0.00 0.00
May	(4)	1.06 0.62	0.05 0.00	0.86 0.40	0.55 0.10	0.00 0.00	0.00 0.00
June	(6)	1.95 0.48	0.53 0.13	5.81 11.25	0.67 0.35	1.18 8.33	0.00 0.00
July	(9)	2.09 1.14	1.25 0.47	6.16 13.81	0.70 0.73	54.62 1636.00	0.00 0.00
August	(6)	2.14 0.67	2.10 9.31	5.47 4.76	1.14 0.27	20.03 108.40	0.00 0.00
September	(3)	1.69 0.32	0.71 0.04	8.49 6.66	1.24 0.03	2.36 16.66	0.00 0.00
October	(3)	1.58 1.03	2.10 2.31	5.23 9.58	1.10 0.04	16.50 216.80	0.00 0.00
November	(3)	1.47 0.07	0.84 0.06	4.00 3.77	1.18 0.10	18.86 217.60	2.36 16.66
December	(3)	0.47 0.01	0.16 0.00	2.39 0.19	0.53 0.02	9.40 66.27	0.00 0.00

<sup>a/</sup> Epischura and Leptodora were measured as number per m<sup>3</sup>.

Table D3. Mean zooplankton densities (no./l) (top line) and variances (bottom line) estimated from 0-30 m vertical tows made in the Tenmile area of Libby Reservoir during 1985.

Month	(N)	Daphnia	Bosmina	Cyclops	Diaptomus	Epischura <sup>a/</sup>	Leptodora <sup>a/</sup>
January	(3)	0.89 0.07	0.15 0.00	5.69 2.33	0.91 0.02	2.36 16.66	0.00 0.00
April	(4)	0.76 0.13	0.16 0.01	11.16 90.75	1.25 0.32	1.77 12.50	0.00 0.00
May	(7)	1.01 0.44	0.21 0.04	9.66 64.27	0.80 0.48	1.01 7.14	0.00 0.00
June	(7)	4.76 1.31	3.55 6.62	12.10 176.30	1.08 0.70	71.74 10966.00	0.00 0.00
July	(7)	2.39 0.62	2.76 12.11	4.68 11.40	1.13 0.24	21.06 209.20	27.63 1099.00
August	(6)	0.88 1.37	0.15 0.02	2.03 5.18	2.40 2.12	0.16 0.03	0.00 0.00
September	(6)	0.87 0.22	0.98 1.04	1.49 0.11	4.20 0.74	0.01 0.00	0.00 0.00
October	(6)	1.08 0.42	0.99 0.17	2.96 0.70	7.29 12.04	0.02 0.00	0.00 0.00
November	(3)	0.67 0.01	0.17 0.00	1.45 0.16	1.09 0.12	0.01 0.00	0.00 0.00
December	(3)	0.74 0.12	0.22 0.01	2.23 3.62	1.70 0.82	0.01 0.00	0.00 0.00

<sup>a/</sup> Epischura and Leptodora were measured as number per m<sup>3</sup>.

Table D4. Mean zooplankton densities (no./l) (top line) and variances (bottom line) estimated from 0-30 m vertical tows made in the Tenmile area of Libby Reservoir during 1986.

Month	(N)	Daphnia	Bosmina	Cyclops	Diaptomus	Epischura*	Leptodora*
January	(3)	0.81 0.04	0.08 0.00	2.09 1.12	2.00 0.14	2.36 16.66	0.00 0.00
April	(3)	1.66 3.73	0.03 0.00	2.74 6.08	1.27 0.33	0.00 0.00	0.00 0.00
May	(6)	4.08 19.00	0.02 0.00	3.88 17.56	1.53 4.86	23.52 1505.00	0.00 0.00
June	(6)	3.07 4.46	0.03 0.00	7.18 13.48	1.22 0.22	21.21 680.00	0.00 0.00
July	(6)	3.12 8.84	0.02 0.00	3.03 0.31	1.61 1.97	23.57 313.90	0.00 0.00
August	(6)	1.10 0.32	0.00 0.00	2.53 0.82	2.76 1.34	12.95 68.40	9.43 193.70
September	(6)	2.83 2.62	0.02 0.00	1.56 0.48	5.51 3.12	4.71 73.25	0.00 0.00

a/ Epischura and Leptodora were measured as number per m<sup>3</sup>.

Table D5. Mean zooplankton densities (no./l) (top line) and variances (bottom line) estimated from 0-30 m vertical tows made in the Tenmile area of Libby Reservoir during 1987.

Month	(N)	Daphnia	Bosmina	Cyclops	Diaptomus	Epischura <sup>a/</sup>	Leptodora <sup>a/</sup>
January	(1)	0.50 *****	0.01 *****	1.49 *****	0.85 *****	0.00 *****	0.00 *****
March	(3)	0.28 0.00	0.01 0.00	0.86 0.01	0.94 0.24	2.36 16.66	0.00 0.00
April	(4)	1.03 0.71	0.03 0.00	1.22 1.56	1.47 1.19	0.00 0.00	0.00 0.00
May	(4)	2.05 1.39	0.17 0.01	19.50 19.06	2.31 0.71	99.50 8686.00	0.00 0.00
June	(4)	1.58 0.88	0.59 0.20	7.58 52.50	0.33 0.03	15.89 79.40	0.00 0.00
July	(3)	0.96 0.68	0.35 0.05	5.10 2.65	0.83 0.07	7.06 49.70	0.00 0.00
September	(3)	1.31 0.23	0.59 0.03	4.70 1.98	0.74 0.00	42.43 149.80	0.00 0.00

<sup>a/</sup> Epischura and Leptodora were measured as number per m<sup>3</sup>.

Table D6. Mean zooplankton densities (no./l) (top line) and variances (bottom line) estimated from 0-30 m vertical tows made in the Tenmile area of Libby Reservoir during 1983-1987.

Month	(N)	Daphnia	Bosmina	Cyclops	Diaptomus	Epischura <sup>a/</sup>	Leptodora <sup>a/</sup>
January	(12)	0.70 0.05	0.06 0.01	3.45 3.40	1.28 0.29	9.43 257.80	0.00 0.00
February	(1)	4.57 *****	0.11 *****	5.28 *****	3.02 *****	0.00 *****	0.00 *****
March	(5)	0.28 0.00	0.02 0.00	1.10 0.14	0.95 0.18	2.83 15.00	0.00 0.00
April	(15)	0.93 0.92	0.07 0.00	4.13 40.33	1.17 0.47	0.47 3.33	0.00 0.00
May	(21)	2.10 6.99	0.12 0.02	8.21 69.27	1.25 1.90	26.01 3117.00	0.00 0.00
June	(23)	3.03 3.25	1.33 4.17	8.39 67.58	0.88 0.44	30.44 3996.00	0.00 0.00
July	(25)	2.29 2.85	1.27 4.34	4.86 9.23	1.06 0.85	32.06 989.50	7.74 435.00
August	(19)	1.34 0.97	0.72 3.53	3.32 5.30	2.08 1.53	10.47 123.20	2.98 74.08
September	(22)	1.71 1.46	0.51 0.41	3.46 8.89	3.59 6.10	9.96 250.70	0.00 0.00
October	(14)	1.36 0.64	0.88 1.07	3.11 3.53	3.86 14.25	7.08 84.40	0.00 0.00
November	(7)	1.07 0.19	0.43 0.17	2.59 3.05	1.20 0.11	9.09 162.20	1.01 7.14
December	(8)	0.56 0.06	0.14 0.01	2.07 1.29	1.10 0.55	3.53 42.58	0.00 0.00

<sup>a/</sup> Epischura and Leptodora were measured as number per m<sup>3</sup>.

Table D7. Mean zooplankton densities (no./l) (top line) and variances (bottom line) estimated from 0-30 m vertical tows made in the Rexford area of Libby Reservoir during 1983.

Month	(N)	<u>Daphnia</u>	<u>Bosmina</u>	<u>Cyclops</u>	<u>Diaptomus</u>	<u>Epischura</u> <sup>a/</sup>	<u>Leptodora</u> <sup>a/</sup>
September	(4)	1.03	0.05	3.62	3.91	18.88	0.00
		0.67	0.00	11.24	12.11	211.60	0.00
October	(4)	0.86	0.02	2.21	2.57	5.29	0.00
		0.21	0.00	0.48	0.67	45.58	0.00
November	(3)	0.49	0.01	2.00	1.72	7.06	0.00
		0.00	0.00	0.00	0.04	49.70	0.00
December	(2)	0.56	0.01	2.57	0.81	7.07	0.00
		0.03	0.00	2.44	0.27	0.00	0.00

<sup>a/</sup> Epischura and Leptodora were measured as number per m<sup>3</sup>.

Table D8. Mean zooplankton densities (no./l) (top line) and variances (bottom line) estimated from 0-30 m vertical tows made in the Rexford area of Libby Reservoir during 1984.

Month	(N)	<u>Daphnia</u>	<u>Bosmina</u>	<u>Cyclops</u>	<u>Diaptomus</u>	<u>Epischura</u> <sup>a/</sup>	<u>Leptodora</u> <sup>a/</sup>
January	(2)	2.13 1.90	0.04 0.00	5.05 3.13	3.10 2.42	7.05 99.41	0.00 0.00
February	(2)	2.51 0.00	0.43 0.28	3.36 2.83	2.10 0.03	4.25 36.04	0.00 0.00
March	(2)	0.99 0.04	0.05 0.00	3.76 1.14	1.20 0.12	0.00 0.00	0.00 0.00
April	(4)	1.95 1.98	0.04 0.00	6.11 9.56	1.19 0.47	0.00 0.00	0.00 0.00
May	(4)	5.41 12.65	0.38 0.10	21.51 434.10	3.77 15.37	6.78 69.14	0.00 0.00
June	(6)	2.44 3.05	1.15 0.21	7.87 20.66	0.85 0.34	3.53 34.82	0.00 0.00
July	(6)	2.19 0.84	0.94 0.07	6.75 28.21	0.83 0.90	24.73 95.07	1.18 8.33
August	(9)	1.67 0.39	0.66 0.18	4.45 4.98	1.28 0.09	26.04 644.30	0.00 0.00
September	(3)	0.31 0.00	1.86 1.06	2.80 0.29	1.63 2.36	72.30 1189.00	0.00 0.00
October	(6)	1.89 2.99	2.02 1.88	3.40 4.79	1.65 0.56	29.46 508.60	0.00 0.00
November	(3)	0.50 0.08	0.11 0.00	2.13 1.24	0.68 0.16	21.19 349.80	0.00 0.00
December	(3)	0.65 0.03	0.22 0.11	2.05 0.13	0.53 0.06	9.43 267.00	0.00 0.00

<sup>a/</sup> Epischura and Leptodora were measured as number per m<sup>3</sup>.

Table D9. Mean zooplankton densities (no./l) (top line) and variances (bottom line) estimated from 0-30 m vertical tows made in the Rexford area of Libby Reservoir during 1985.

Month	(N)	<u>Daphnia</u>	<u>Bosmina</u>	<u>Cyclops</u>	<u>Diaptomus</u>	<u>Epischura</u> <sup>a/</sup>	<u>Leptodora</u> <sup>a/</sup>
February	(1)	0.91 *****	0.11 *****	6.08 *****	5.09 *****	0.00 *****	0.00 *****
April	(6)	0.40 0.02	0.17 0.01	9.62 45.00	0.81 0.19	0.00 0.00	0.00 0.00
May	(6)	0.40 0.05	0.26 0.02	11.49 35.40	0.22 0.03	5.19 45.47	0.00 0.00
June	(6)	5.17 9.53	5.17 13.27	5.70 5.19	0.86 0.45	20.43 523.40	4.32 25.41
July	(6)	3.97 12.58	0.16 0.02	6.29 34.17	1.92 2.44	4.88 11.61	12.96 268.00
August	(6)	1.04 0.77	0.07 0.03	3.63 4.10	3.80 2.31	0.08 0.00	0.00 0.00
September	(6)	1.55 0.77	0.19 0.01	5.28 69.42	5.73 10.89	0.02 0.00	0.00 0.00
October	(5)	1.33 0.37	0.39 0.08	2.65 0.96	4.56 6.41	0.01 0.00	0.00 0.00
November	(3)	0.84 0.05	0.24 0.02	2.10 0.24	2.54 0.18	0.01 0.00	0.00 0.00

<sup>a/</sup> Epischura and Leptodora were measured as number per m<sup>3</sup>.

Table D10. Mean zooplankton densities (no./l) (top line) and variances (bottom line) estimated from 0-30 m vertical tows made in the Rexford area of Libby Reservoir during 1986.

Month	(N)	<u>Daphnia</u>	<u>Bosmina</u>	<u>Cyclops</u>	<u>Diaptomus</u>	<u>Epischura</u> <sup>a/</sup>	<u>Leptodora</u> <sup>a/</sup>
January	(3)	3.06 1.60	0.11 0.00	1.16 0.55	2.42 0.41	0.00 0.00	0.00 0.00
April	(3)	0.25 0.13	0.01 0.00	0.21 0.01	0.17 0.00	0.00 0.00	0.00 0.00
May	(6)	5.31 35.36	0.03 0.00	8.60 93.24	1.55 1.94	20.50 682.90	0.79 3.71
June	(6)	2.62 9.13	0.02 0.00	5.62 10.22	1.36 2.37	7.27 40.03	0.00 0.00
July	(6)	1.00 0.08	0.00 0.00	4.93 2.17	2.96 0.53	10.59 54.83	2.36 13.33
August	(6)	1.01 0.99	0.00 0.00	2.56 5.82	3.26 4.36	11.78 73.41	1.18 8.33
September	(3)	0.91 0.30	0.00 0.00	1.73 1.20	4.00 4.83	43.82 3327.00	0.00 0.00
October	(3)	1.00 0.82	0.00 0.00	1.06 0.15	2.03 0.68	14.10 0.00	0.00 0.00

<sup>a/</sup> Epischura and Leptodora were measured as number per m<sup>3</sup>.

Table D11 Mean zooplankton densities (no./l) (top line) and variances (bottom line) estimated from 0-30 m vertical tows made in the Rexford area of Libby Reservoir during 1987.

Month	(N)	<u>Daphnia</u>	<u>Bosmina</u>	<u>Cyclops</u>	<u>Diaptomus</u>	<u>Epischura</u> <sup>a/</sup>	<u>Leptodora</u> <sup>a/</sup>
March	(3)	0.61 0.14	0.00 0.00	0.83 0.39	1.41 1.31	0.00 0.00	0.00 0.00
April	(3)	1.15 3.62	0.00 0.00	2.42 13.72	2.44 15.76	0.00 0.00	0.00 0.00
May	(3)	0.27 0.05	0.01 0.00	3.26 5.29	0.28 0.08	4.12 27.32	0.00 0.00
June	(3)	7.35 19.93	0.90 0.41	17.30 21.99	2.28 4.84	21.19 349.80	0.00 0.00
July	(3)	1.81 0.12	0.12 0.00	3.95 1.98	1.64 0.71	12.63 2.61	5.78 30.02
September	(3)	1.17 0.45	0.82 0.07	4.07 0.81	0.56 0.00	42.43 350.70	0.00 0.00

<sup>a/</sup> Epischura and Leptodora were measured as number per m<sup>3</sup>.

Table D12 Mean zooplankton densities (no./l) (top line) and variances (bottom line) estimated from 0-30 m vertical tows made in the Rexford area of Libby Reservoir during 1983-1987.

Month	(N)	<u>Daphnia</u>	<u>Bosmina</u>	<u>Cyclops</u>	<u>Diaptomus</u>	<u>Epischura</u> <sup>a/</sup>	<u>Leptodora</u> <sup>a/</sup>
January	(5)	2.69 1.54	0.08 0.00	2.72 5.60	2.69 0.95	2.82 39.76	0.00 0.00
February	(3)	1.97 0.85	0.32 0.17	4.27 3.88	3.09 3.00	2.83 24.03	0.00 0.00
March	(5)	0.76 0.12	0.02 0.00	2.01 3.06	1.32 0.70	0.00 0.00	0.00 0.00
April	(16)	0.90 1.40	0.07 0.01	5.63 33.09	1.09 2.82	0.00 0.00	0.00 0.00
May	(19)	2.98 18.51	0.17 0.05	11.39 145.00	1.40 5.05	10.19 269.40	0.25 1.17
June	(21)	3.97 10.81	1.94 8.01	7.95 27.49	1.20 1.53	11.95 246.80	1.24 10.36
July	(21)	2.30 4.77	0.33 0.18	5.70 17.40	1.87 1.73	13.29 103.40	5.54 100.70
August	(21)	1.30 0.71	0.30 0.18	3.68 5.12	2.56 3.06	14.55 400.60	0.34 2.38
September	(19)	1.09 0.59	0.49 0.57	3.79 23.04	3.61 9.60	29.01 1258.00	0.00 0.00
October	(18)	1.36 1.28	0.79 1.40	2.54 2.42	2.73 3.36	13.35 317.00	0.00 0.00
November	(9)	0.61 0.06	0.12 0.01	2.08 0.37	1.65 0.75	9.42 187.10	0.00 0.00
December	(5)	0.61 0.02	0.14 0.07	2.25 0.76	0.64 0.12	8.49 135.20	0.00 0.00

<sup>a/</sup> Epischura and Leptodora were measured as number per m<sup>3</sup>.

Table D13 Mean zooplankton densities (no./l) (top line) and variances (bottom line) estimated from 0-30 m vertical tows made in the Canada area of Libby Reservoir during 1983.

Month	(N)	<u>Daphnia</u>	<u>Bosmina</u>	<u>Cyclops</u>	<u>Diaptomus</u>	<u>Epischura</u> <sup>a/</sup>	<u>Leptodora</u> <sup>a/</sup>
September	(4)	2.81	0.09	3.26	4.51	15.74	0.00
		1.55	0.00	1.02	1.74	74.53	0.00
October	(4)	3.59	0.10	4.25	5.09	3.53	0.00
		2.10	0.01	1.06	4.84	49.70	0.00
November	(2)	10.47	0.54	6.38	7.61	7.05	0.00
		0.00	0.00	0.00	0.00	99.41	0.00

<sup>a/</sup> Epischura and Leptodora were measured as number per m<sup>3</sup>.

Table D14 Mean zooplankton densities (No./l) (top line) and variances (bottom line) estimated from 0-30 m vertical tows made in the Canada area of Libby Reservoir during 1984.

Month	(n)	<u>Daphnia</u>	<u>Bosmina</u>	<u>Cyclops</u>	<u>Diaptomus</u>	<u>Epischura</u> <sup>a/</sup>	<u>Leptodora</u> <sup>a/</sup>
July	(6)	4.85 34.35	0.33 0.50	8.17 40.82	2.63 6.54	8.97 193.80	0.00 0.00
August	(8)	3.99 2.59	0.30 0.07	2.91 2.04	0.83 0.16	44.63 2809.00	0.00 0.00
September	(3)	0.87 0.29	1.10 0.25	2.20 0.09	0.61 0.06	50.90 1018.00	0.00 0.00
October	(6)	6.51 34.74	6.79 43.05	7.73 15.17	2.65 3.06	22.91 292.50	1.18 8.33
November	(3)	2.77 9.32	1.80 2.43	5.65 20.68	2.14 2.77	17.50 289.80	0.00 0.00

<sup>a/</sup> Epischura and Leptodora were measured as number per m<sup>3</sup>.

Table D15 Mean zooplankton densities (no./l) (top line) and variances (bottom line) estimated from 0-30 m vertical tows made in the Canada area of Libby Reservoir during 1985.

Month	(N)	<u>Daphnia</u>	<u>Bosmina</u>	<u>Cyclops</u>	<u>Diaptomus</u>	<u>Epischura</u> <sup>a/</sup>	<u>Leptodora</u> <sup>a/</sup>
June	(5)	4.06 30.78	0.17 0.12	2.90 19.03	0.26 0.15	0.00 0.00	1.89 17.78
July	(2)	4.22 15.24	0.01 0.00	1.14 1.04	0.54 0.00	2.95 17.35	7.45 111.00
August	(12)	2.52 4.31	0.04 0.00	3.78 1.84	3.08 7.00	13.39 1434.00	13.77 865.30
September	(6)	3.99 18.83	0.48 0.14	7.81 16.67	14.44 163.30	0.06 0.01	0.01 0.00
October	(6)	4.29 18.45	1.04 2.14	10.03 47.94	12.67 136.70	0.02 0.00	0.00 0.00
November	(3)	4.31 55.38	0.14 0.03	6.44 122.00	10.98 360.5	0.00 0.00	0.00 0.00

<sup>a/</sup> Epischura and Leptodora were measured as number per m<sup>3</sup>.

Table D16 Mean zooplankton densities (no./l) (top line) and variances (bottom line) estimated from 0-30 m vertical tows made in the Canada area of Libby Reservoir during 1986.

Month	(N)	<u>Daphnia</u>	<u>Bosmina</u>	<u>Cyclops</u>	<u>Diaptomus</u>	<u>Epischura</u> <sup>a/</sup>	<u>Leptodora</u> <sup>a/</sup>
June	(3)	7.65	0.05	9.74	4.37	40.57	8.73
		104.0	0.00	43.17	9.53	753.3	78.37
July	(6)	2.55	0.00	6.77	6.40	7.77	7.10
		1.48	0.00	23.90	24.60	203.3	33.78
August	(6)	2.22	0.01	3.59	1.71	9.22	1.18
		1.02	0.00	4.90	2.55	125.3	8.33
September	(6)	3.02	0.07	3.75	2.92	7.59	1.57
		5.64	0.00	5.92	1.02	39.57	14.82

<sup>a/</sup> Epischura and Leptodora were measured as number per m<sup>3</sup>.

Table D17 Mean zooplankton densities (no./l) (top line) and variances (bottom line) estimated from 0-30 m vertical tows made in the Canada area of Libby Reservoir during 1987.

Month	(N)	<u>Daphnia</u>	<u>Bosmina</u>	<u>Cyclops</u>	<u>Diaptomus</u>	<u>Epischura</u> <sup>a/</sup>	<u>Leptodora</u> <sup>a/</sup>
June	(3)	8.75	0.00	10.28	2.57	0.00	2.36
		3.83	0.00	2.47	1.23	0.00	16.66
July	(3)	5.18	0.01	4.16	2.18	18.35	5.24
		1.58	0.00	3.20	1.04	639.50	20.59
September	(3)	2.03	4.49	5.02	1.73	62.13	0.00
		0.92	0.86	6.19	0.28	1626.00	0.00

<sup>a/</sup> Epischura and Leptodora were measured as number per m<sup>3</sup>.

Table D18 Mean zooplankton densities (no./l) (top line) and variances (bottom line) estimated from 0-30 m vertical tows made in the Canada area of Libby Reservoir during 1983-1987.

Month	(N)	<u>Daphnia</u>	<u>Bosmina</u>	<u>Cyclops</u>	<u>Diaptomus</u>	<u>Epischura</u> <sup>a/</sup>	<u>Leptodora</u> <sup>a/</sup>
June	(11)	6.32 38.71	0.09 0.05	6.78 30.59	2.01 5.51	11.06 509.70	3.88 35.86
July	(17)	4.02 13.67	0.12 0.18	6.14 26.25	3.64 14.69	9.49 226.40	4.31 31.34
August	(26)	2.90 3.39	0.11 0.04	3.47 2.51	2.07 4.65	22.04 1681.00	6.63 428.00
September	(22)	2.82 7.20	0.93 2.36	4.73 10.44	5.87 69.63	20.36 822.90	0.43 4.04
October	(16)	4.95 19.79	2.96 24.58	7.72 26.60	7.02 68.96	9.48 224.90	0.44 3.12
November	(8)	5.27 29.29	0.86 1.33	6.13 40.94	6.82 120.80	8.33 163.20	0.00 0.00

<sup>a/</sup> Epischura and Leptodora were measured as number per m<sup>3</sup>.

APPENDIX E  
Figures E1 and E2

Distribution of the percent total Daphnia by size class  
in Libby Reservoir, 1983 through 1987.

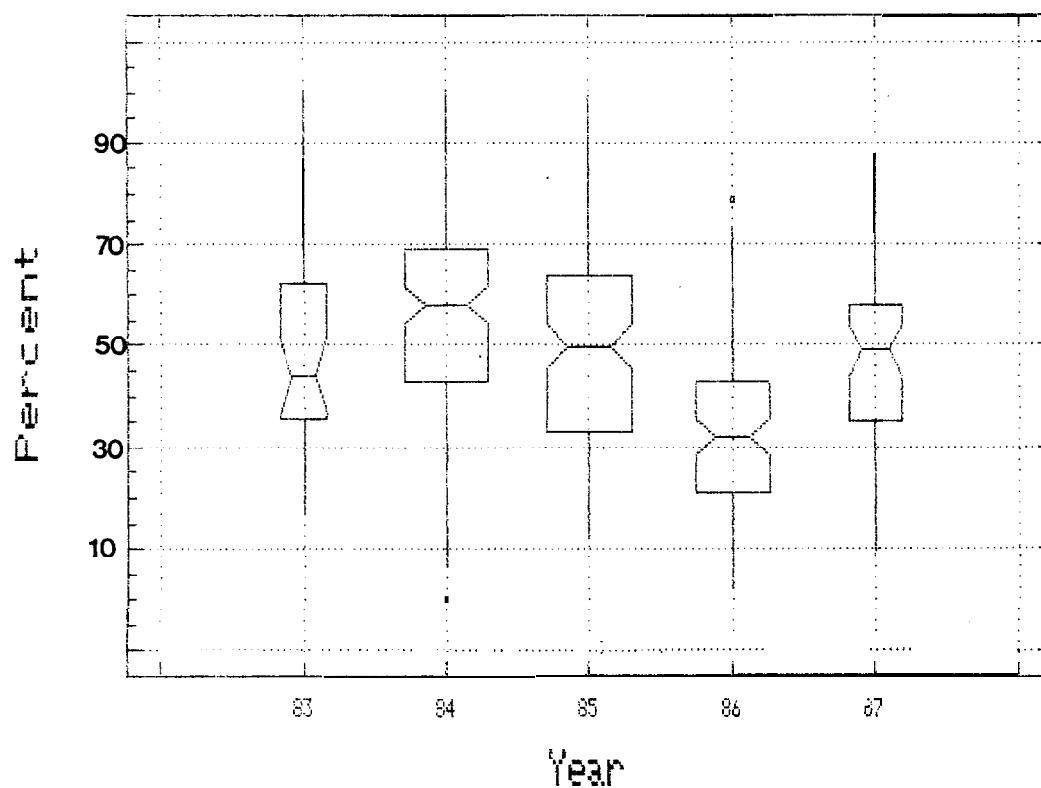


Figure E1. Distribution of the percent total Daphnia in the 0.50 to 0.99 mm size class for 1983 to 1987, Libby Reservoir. Horizontal lines indicate median values; boxes enclose the middle 50 percent of the values; solid vertical lines extend to 1.5 times the interquartile range; outlier values beyond solid line are indicated as dots; notches in box indicate 95 percent confidence level of median value; width of box is proportional to the square root of the number of observations in the sample.

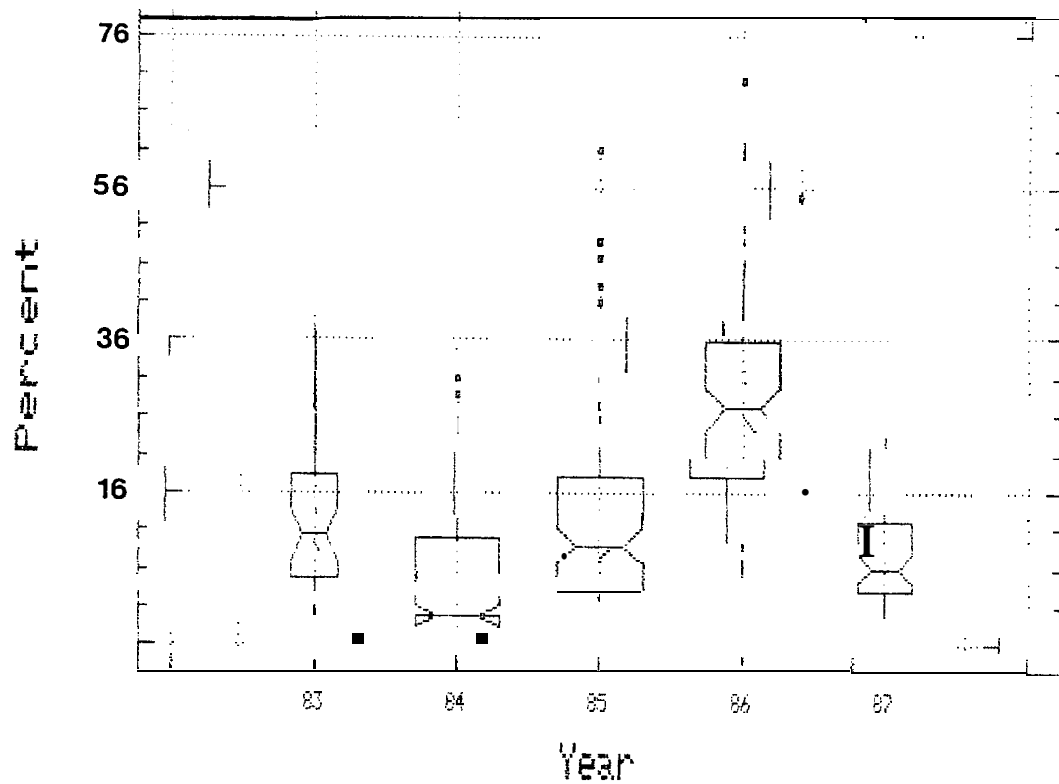


Figure E2. Distribution of the percent total Daphnia in the 1.5 mm to 1.9 mm size class for 1983 to 1987, Libby Reservoir. Horizontal lines indicate median values; boxes enclose the middle 50 percent of the values; solid vertical lines extend to 1.5 times the interquartile range; outlier values beyond solid line are indicated as dots; notches in box indicate 95 percent confidence level of median value; width of box is proportional to the square root of the number of observations in the sample.

## APPENDIX F

Tables F1 through F15.

Monthly and yearly average densities and yearly average lengths  
of zooplankton samples from Schindler traps  
in three areas of Libby Reservoir,  
1983 through 1987.

Table F1. Monthly average density (N/L) of *Daphnia* in the Termile area of Libby Reservoir at depths, 1983 through 1987. Values in parentheses are the standard deviations. For entire population:  $\bar{x}$ =1.8282, SD=2.9864, N=369.

Depth	Jan N=4	Feb	Mar N=2	Apr N=3	May N=4	Jun N=4	Jul N=5	Aug N=3	Sep N=4	Oct N=5	Nov N=3	Dec N=4
Surface, N=41 $\bar{x}$ =4.678 SD=.8568	.0975 (.0602)		.0150 .0212	.0433 .0513	1.7225 2.0493	.7200 1.0554	.5440 .3438	.4100 .6582	.1525 .1047	.7200 .7510	.1167 .0808	.0875 .0479)
3m, N=41 $\bar{x}$ =4.3188 SD=5.5246	1.1525 (1.411		.0700 .0000	.3100 .0458	11.2925 10.4140	10.6100 4.6436	7.6800 5.4289	4.1200 1.9226	2.2350 4.4321	3.6040 3.6108	.9433 .6868	.7175 .7990)
6m, N=41 $\bar{x}$ =3.3239 se3.3886	1.0125 (.8578		.1750 .0071	.2933 .2401	3.5950 4.1126	8.5850 3.4743	6.6380 2.1634	4.0833 1.8354	2.0275 1.1428	4.1740 3.7315	1.4067 1.00335	.8650 .6946)
9m, N=41 $\bar{x}$ =2.8617 SD=3.8327	1.1650 (.7752		.0850 .1202	.1867 .1692	6.0550 10.3024	5.6675 3.8984	4.3640 1.0654	4.2533 1.8627	2.4050 1.6660	2.7820 3.0028	1.3700 .4939	.7075 .6950)
12m, N=41 $\bar{x}$ =1.9793 SD=2.4071	1.0075 (1.3377		.0700 .0424	.1567 .1026	3.7325 6.3941	3.3425 1.9877	2.2360 .6130	4.3533 1.8604	1.9150 1.1778	1.8560 1.5342	1.6967 1.1046	.4850 .1870)
15m, N=41 $\bar{x}$ =1.2534 SD=1.1718	.8650 (.4596		.0650 .0919	.2033 .0833	1.5800 1.6937	1.4925 .7345	1.8440 10.637	2.2311 2.2864	1.4075 1.4911	1.6320 1.2381	1.3400 .2207	.6450 .4012)
20m, N=41 $\bar{x}$ =.7871 SD=.6218	.7000 (.6944		.0350 .0495	.2233 .1595	.9700 .9195	.9375 .6284	1.0360 .5362	.7433 .3668	.8375 .7604	.7580 .6756	1.4967 .5300	.5150 .2763)
25m, N=41 $\bar{x}$ =.6902 SD=.5472	.5350 (.3594		.2250 .0636	.1800 .1947	.9375 .6658	1.1100 .8341	.6100 .6922	.5833 .2631	.5050 .2978	.7440 .5357	1.3533 .1361	.5950 .5014)
30m, N=41 $\bar{x}$ =.7717 SD=1.0881	.4800 (.3908		.1000 .1414	.1667 .2082	.6750 .4576	.8800 .4036	2.0120 2.7470	.4267 .3101	.4300 .3316	.5140 .4348	1.5400 .3100	.6375 .5504)

Table F2. Monthly average density (N/L) of Bosmina in the Tennile area of Libby Reservoir at discrete depths, 1983 through 1987. Values in parentheses are the standard deviations. For entire population:  $\bar{x}$ =1.8319, SD=2.6398, N=369.

Depth	Jan N=4	Feb	Mar N=2	Apr N=3	May N=4	Jun N=4	Jul N=5	Aug N=3	Sep N=4	Oct N=5	Nov N=3	Dec N=4
Surface, N=41 $\bar{x}$ =.1390 SD=.2800	.0275 (.0550)		.000 .000	.000 .000	.0175 .0350	.4175 .4639	.3820 .4962	.0133 .0231	.1500 .3000	.1840 .2652	.0800 .0781	.0350 .0472)
3m, N=41 $\bar{x}$ =1.0946 SD=2.7489	.0375 (.0514)		.0150 .0212	.0200 .0173	.0350 .0520	3.7850 4.7274	1.8140 2.2853	.1500 .1323	1.1000 1.7082	2.7940 5.8267	.4333 .5341	.0425 .0189)
6m, N=41 $\bar{x}$ =1.8549 SD=4.9101	.0975 (.1493)		.000 .000	.000 .000	.0525 .0427	6.0700 8.4674	4.5500 8.0459	.3467 .3961	1.1175 1.6486	4.0820 8.3601	.7033 .8882	.0600 .1010)
9m, N=41 E1.6273 SD=4.2458	.1600 (.2939)		.000 .000	.0333 .0351	.0700 .0787	4.990 7.8547	4.1820 7.3587	.6167 .5393	1.1775 1.6122	3.1740 6.5671	.6733 .7553	.0950 .1100)
12m, N=41 $\bar{x}$ =1.0320 SD=2.5311	.1075 (.1692)		.000 .000	.0100 .0173	.0775 .0802	3.1550 5.7034	1.8600 3.1347	1.2633 1.2314	.7100 .8796	2.1060 4.1067	.7633 1.0494	.0450 .0545)
15m, N=41 $\bar{x}$ =.6720 SD=2.5311	.0775 (.1001)		.0350 .0495	.0233 .0404	.0425 .0340	2.1200 4.1867	1.880 2.0025	.2067 1.1801	.7375 .8367	1.3260 2.4451	.5967 .7366	.1300 .1186)
20m, N=41 $\bar{x}$ =.4156 SD=.9948	.0275 (.0189)		.0200 .0283	.0467 .0503	.0175 .0350	1.327 2.5160	.5060 .6521	.1167 .1012	.5600 .7614	.8520 1.5038	.5833 .6475	.0600 .0952)
25m, N=41 $\bar{x}$ =.3151 SD=.7464	.0350 (.0473)		.000 .000	.000 .000	.0275 .0550	1.1100 2.061	.4280 .4896	.0600 .0557	.3675 .4584	.5120 .8668	.4667 .5033	.1200 .1470)
30m, N=41 $\bar{x}$ =.3366 SD=.6840	.0500 (.0627)		.000 .000	.000 .000	.0175 .0206	.8025 1.4461	.4740 .4601	.1133 .1060	.3325 .4714	.7360 1.2191	.7400 .6994	.0950 .1100)

Table F3. Monthly average density (N/L) of Cyclops in the Tenmile area of Libby Reservoir at depths, 1983 through 1987. Values in parentheses are the standard deviations. For entire population:  $\bar{x}=4.2535$ ,  $SD=6.3223$ ,  $N=369$ .

Depth	Jan N=4	Feb	Mar N=2	Apr N=3	May N=4	Jun N=4	Jul N=5	Aug N=3	Sep N=4	Oct N=5	Nov N=3	Dec N=4
Surface, N=41 $\bar{x}=2.6354$ $SD=5.7385$	1.81 (.67)		.18 .11	.31 .40	11.06 16.34	2.53 3.49	<b>2.46</b> 3.42	2.93 4.92	1.27 1.57	2.64 2.17	<b>1.13</b> .76	.56 (.49)
3m, N=41 $\bar{x}=9.1695$ $SD=13.3380$	5.12 (5.61)		.45 .03	2.10 1.60	25.79 30.20	<b>18.70</b> <b>15.63</b>	<b>17.82</b> <b>12.02</b>	<b>6.46</b> 3.36	<b>4.07</b> 1.49	6.01 7.22	2.83 <b>1.07</b>	<b>1.77</b> <b>1.09</b>
6m, N=41 $\bar{x}=6.4876$ $SD=7.3220$	5.56 (4.47)		.84 .01	2.51 1.44	8.72 4.12	<b>16.58</b> <b>13.30</b>	14.16 7.81	4.38 <b>2.96</b>	3.65 2.42	6.53 7.32	3.97 .72	1.28 (.84)
9m, N=41 $\bar{x}=5.6317$ $SD=4.9422$	6.34 (5.56)		.76 .67	1.66 1.06	80.2 5.72	9.33 6.44	10.08 6.00	5.23 <b>3.03</b>	3.50 1.79	5.50 5.61	3.35 .95	3.02 (2.84)
12m, N=41 $\bar{x}=4.1320$ $SD=3.3606$	5.09 (4.34)		.51 .32	1.30 .96	4.64 <b>4.07</b>	6.23 4.67	6.91 <b>3.12</b>	5.32 3.11	<b>2.90</b> <b>1.61</b>	<b>4.08</b> 3.47	4.16 2.49	1.42 (.77)
15m, N=41 $\bar{x}=3.3437$ $SD=2.6023$	.07 (4.07)		.77 .93	<b>1.60</b> .90	4.04 4.02	3.52 1.93	4.80 3.16	<b>4.15</b> 3.56	3.11 1.91	3.14 2.65	3.47 .75	2.39 (0.84)
20m, N=41 $\bar{x}=2.2851$ $SD=1.6195$	2.72 (2.73)		.66 .77	1.26 1.36	2.88 <b>2.62</b>	2.45 <b>1.88</b>	2.47 .71	2.26 <b>1.13</b>	1.83 <b>1.13</b>	2.29 <b>1.95</b>	3.75 .98	1.81 (.93)
25m, N=41 $\bar{x}=2.1512$ $SD=1.6570$	2.48 (1.73)		1.07 .80	.95 1.17	2.64 <b>2.12</b>	<b>2.12</b> 1.62	<b>1.61</b> 1.32	<b>1.51</b> .26	1.64 1.67	<b>1.90</b> 1.27	4.71 1.97	2.88 (2.04)
30m, N=41 $\bar{x}=2.0851$ $SD=2.2240$	1.76 (1.73)		.39 .45	.74 .57	2.36 2.36	1.93 <b>2.07</b>	3.74 4.38	1.35 .34	1.26 .87	1.45 1.21	4.91 2.55	2.14 (1.21)

Table F4. Monthly average density (N/L) of *Epischura* in the Temile area of Libby Reservoir at discrete depths, 1983 through 1987. Values in parentheses are the standard deviations. For entire population:  $\bar{x}$ =.0174, SD=.0539, N=369.

Depth	Jan N=4	Feb	Mar N=2	Apr N=3	May N=4	Jun N=4	Jul N=5	Aug N=3	Sep N=4	Oct N=5	Nov N=3	Dec N=4
Surface, N=41 $\bar{x}$ =.0110 SD=.039	.000 (.000)		.000 (.000)	.000 (.000)	.0575 .1150	.0175 .0350	.0080 .0179	.000 (.000)	.000 (.000)	.0220 .0319	.000 (.000)	.000 (.000)
3m, N=41 $\bar{x}$ =.03228 SD=.1027	.000 (.000)		.000 (.000)	.000 (.000)	.2250 .2679	.0250 .0500	.0480 .0746	.0133 .0231	.000 (.000)	.0080 .0179	.000 (.000)	.000 (.000)
6m, N=41 $\bar{x}$ =.0163 SD=.0345	.000 (.000)		.000 (.000)	.000 (.000)	.0175 .2679	.0250 .0500	.0720 .0530	.000 (.000)	.0100 .0200	.0140 .0195	.0100 .0173	.000 (.000)
9m, N=41 $\bar{x}$ =.0261 SD=.0693	.000 (.000)		.000 (.000)	.000 (.000)	.0175 .0350	.000 (.000)	.1520 .1436	.0233 .0404	.0250 .0500	.0060 .0134	.000 (.000)	.010 (.000)
12m, N=41 $\bar{x}$ =.0261 SD=.0693	.000 (.000)		.000 (.000)	.000 (.000)	.0075 .0150	.0175 .0350	.1280 .0691	.0233 .0208	.0450 .0480	.0060 .0134	.0133 .0231	.000 (.000)
15m, N=41 $\bar{x}$ =.0146 SD=.0398	.000 (.000)		.000 (.000)	.000 (.000)	.0075 .0150	.000 (.000)	.0820 .0864	.0333 .0351	.0150 .0173	.000 (.000)	.000 (.000)	.000 (.000)
20m, N=41 $\bar{x}$ =.0120 SD=.0419	.000 (.000)		.000 (.000)	.000 (.000)	.000 (.000)	.000 (.000)	.0740 .1062	.0100 .0173	.0075 .0150	.000 (.000)	.0100 .0173	.007 (.015)
25m, N=41 $\bar{x}$ =.0073 SD=.0191	.000 (.000)		.000 (.000)	.000 (.000)	.0075 .0150	.0075 .0150	.0200 .0447	.0133 .0231	.0075 .0150	.0140 .0195	.000 (.000)	.000 (.000)
30m, N=41 $\bar{x}$ =.0115 SD=.0431	.000 (.000)		.000 (.000)	.000 (.000)	.0075 .0150	.000 (.000)	.0600 .1181	.000 (.000)	.0075 .0150	.0080 .0179	.000 (.000)	.0175 (.021)

Table F5. Monthly average density (N/L) of Diaptomus in the Tenmile area of Libby Reservoir at discrete depths, 1983 through 1987. Values in parentheses are the standard deviations. For entire population:  $\bar{x}$ =1.9250, SD=3.2138, N=369.

Depth	Jan N=4	Feb	Mar N=2	Apr N=3	May N=4	Jun N=4	Jul N=5	Aug N=3	Sep N=4	Oct N=5	Nov N=3	Dec N=4
Surface, N=41 $\bar{x}$ =1.7080 SD=	.36 (.28)		.14 .198	.39 .34	10.72 12.04	.37 .28	.59 .64	1.01 .68	1.26 1.97	1.70 1.47	.69 .68	.31 .22)
3m, N=41 $\bar{x}$ =3.7302 SD=5.2191	0.26 (1.01)		.2750 .1344	1.53 .31	8.65 8.07	2.49 1.63	5.36 6.19	4.18 1.94	9.49 10.43	2.60 1.98	.72 .33	1.45 2.09)
6m, N=41 $\bar{x}$ =2.5776 SD=3.2587	1.68 (1.698)		.47 .14	1.39 .72	1.47 .42	1.53 .89	3.63 2.60	3.13 1.45	7.20 7.76	3.84 3.62	1.04 .47	.80 .89)
9m, N=41 $\bar{x}$ =2.3 SD=3.16	1.305 (1.11)		.60 .24	.94 .51	1.54 .99	.97 1.03	2.23 1.59	4.23 2.87	6.82 7.10	3.63 4.01	1.03 .583	1.63 2.13)
12m, N=41 $\bar{x}$ =1.9505 SD=2.8841	1.3 (1.31)		.39 .40	.70 .72	1.07 1.35	.53 .522	1.37 .94	4.12 3.04	6.24 6.39	2.98 3.49	1.31 .35	.64 1.1)
15m, N=41 $\bar{x}$ =1.7934 SD=2.7500	1.44 (1.9)		.31 .28	.81 .44	1.21 .76	.29 .26	1.30 1.02	3.10 1.23	6.09 6.72	2.15 3.09	1.29 .77	1.01 1.32)
20m, N=41 $\bar{x}$ =1.1061 SD=1.1962	.89 (.99)		.46 .59	.80 .94	.79 .37	.31 .30	.93 .91	2.1.1 1.10	2.57 2.58	1.10 1.01	1.65 1.19	.59 .53)
25m, N=41 $\bar{x}$ =1.0576 SD=1.1969	.82 (.81)		.46 .45	.68 .65	.72 .41	.21 .17	.48 .60	1.77 .67	2.02 2.08	1.47 1.89	1.82 1.56	1.21 1.28)
30m, N=41 $\bar{x}$ =1.0059 SD=1.1508	.65 (.57)		.44 .62	.62 .67	.76 .58	.27 .21	1.52 1.96	1.02 .67	1.81 1.72	1.06 1.46	1.72 1.53	.87 .73)

Table F6. Monthly average density (N/L) of Daphnia in the Rexford area of Libby Reservoir at discrete depths, 1983 through 1987. Values in parentheses are the standard deviations. For entire population:  $\bar{x}$ =2.26, SD=5.49, N=338.

Depth	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Surface, N=38 $\bar{x}$ =2.05 SD=8.05	.19 (.06 n=2	1.21 .00 n=1	.04 .06 n=3	.02 .02 n=4	.24 .32 n=3	13.73 20.02 n=5	.40 .53 n=3	.55 1.03 n=4	.09 .12 n=2	.22 .31 n=5	.46 .45 n=4	.09 .13) n=2
3m, N=37 E5.248 SD=10.09	3.12 (3.05 n=2	3.17 .00 n=1	1.28 1.10 n=2	.83 1.02 n=4	6.94 8.34 n=3	19.40 21.83 n=5	4.48 1.91 n=3	6.11 7.67 n=4	6.70 8.20 n=2	1.20 .57 n=5	.84 .36 n=4	.14 .10) n=2
6m, N=37 $\bar{x}$ =4.27 SD=7.74	2.00 (1.87 n=2	3.70 .00 n=1	3.87 2.79 n=2	.94 .71 n=4	3.63 3.32 n=3	16.18 16.85 n=5	4.81 1.04 n=3	3.59 2.64 n=4	5.43 7.16 n=2	.81 .47 n=5	.69 .32 n=4	.29 .05) rF2
9m, N=36 $\bar{x}$ =2.70 SD=3.71	2.01 (2.64 n=2	3.27 .00 n=1	1.01 1.32 n=2	1.53 1.51 n=4	2.95 2.50 n=3	7.65 7.67 n=5	4.87 2.53 n=3	2.23 1.02 n=4	2.80 2.31 n=2	.66 .31 n=4	.63 .80 rF4	.18 .01) n=2
12m, N=37 E1.74 SD=2.30	1.61 (2.02 n=2	1.17 .00 n=1	1.02 .64 n=2	.73 .57 n=4	2.71 2.31 n=3	5.61 4.19 n=5	1.15 .10 rF3	1.36 .87 n=4	1.45 .74 n=2	.67 .52 n=5	.77 .37 n=4	.34 1.00) n=2
15m, N=37 E1.27 SD=1.53	1.17 (1.36 n=2	.39 .00 n=1	.51 .57 n=2	.78 .63 n=4	1.79 1.63 n=3	3.51 2.99 n=5	1.25 .28 n=3	1.14 .91 n=4	1.15 .54 n=2	.69 .62 n=5	.73 .67 n=4	.18 1.37) n=2
20m, N=37 $\bar{x}$ =1.00 SD=1.388	1.35 (1.06 n=2	.50 .00 n=1	.33 .01 n=2	.24 .20 n=4	.61 .65 n=3	3.06 2.95 n=5	.99 .42 n=3	.79 .61 n=4	1.00 .57 n=2	.63 .58 n=5	.78 .46 n=4	.38 .08) n=2
25m, N=34 $\bar{x}$ =.96 SD=1.382	.91 (1.08 n=2	.600 .00 n=1	.21 .00 n=1	.13 .11 n=3	1.19 1.17 n=3	3.06 3.23 n=4	.51 .14 n=3	.84 .93 n=4	1.09 .45 n=2	.67 .61 n=5	.61 .40 n=4	.52 .18) n=2
30m, N=35 $\bar{x}$ =.89 SD=1.15	1.26 (1.23 n=2	.00 .00 n=1	.39 .00 n=1	.07 .12 n=3	1.11 1.46 n=3	2.41 2.09 n=4	.46 .20 n=4	1.11 1.18 rF4	.82 .87 n=2	.42 .35 n=5	1.08 1.29 n=4	.38 .08) n=2

Table F7. Monthly average density (N/L) of *Bosmina* in the Rexford area of Libby Reservoir at discrete depths, 1983 through 1987. Values in parentheses are the standard deviations. For entire population:  $\bar{x}=.64$ ,  $SD=2.07$ ,  $N=328$ .

Depth	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Surface, N=38 $\bar{x}=.20$ 5.39	.00 (.00 n=2	.07 (.00 n=1	.00 (.00 n=3	.00 (.00 n=4	.00 (.00 n=3	.65 (.79 n=5	.21 (.34 n=3	.19 (.34 n=4	.22 (.26 n=2	.31 (.47 n=5	.14 (.14 n=4	.04 (NA) n=2
3m, N=37 $\bar{x}=.92$ 8 53.01	.02 (.03 n=2	.14 (.00 n=1	.00 (.00 n=2	.03 (.02 n=4	.20 (.20 n=3	4.00 (7.86 n=5	.38 (.63 n=3	1.26 (1.70 n=4	.77 (.71 n=2	.85 (1.48 n=5	.29 (.35 n=4	.02 (0) n=2
6m, N=37 $\bar{x}=1.08$ 3x3.5	.05 (.07 n=2	.11 (.00 n=1	.04 (.05 n=2	.10 (.17 n=4	.21 (.20 n=3	4.83 (9.18 n=5	.52 (.73 n=3	1.18 (1.89 n=4	1.55 (.78 n=2	.85 (1.09 n=5	.19 (.21 n=4	.02 (.03) rF2
9m, N=36 $\bar{x}=.74$ SD=1.96	.10 (.14 n=2	.00 (.00 n=1	.02 (.03 n=2	.12 (.17 n=4	.22 (.18 n=3	3.02 (4.86 n=5	.52 (.55 n=3	.73 (.92 n=4	1.40 (.10 n=2	.51 (.87 n=4	.18 (.24 n=4	.02 (.03) n=2
12m, N=37 $\bar{x}=.54$ SD=2.14	.07 (.09 n=2	.04 (.00 n=1	.04 (.05 n=2	.10 (.13 n=4	.16 (.14 n=3	2.42 (3.64 n=5	.34 (.43 n=3	.48 (.59 n=4	.88 (.07 n=2	.22 (.33 n=5	.22 (.27 n=4	.04 (.05) n=2
15m, N=37 $\bar{x}=.69$ 3X2.14	.14 (.00 n=2	.07 (.00 n=1	.06 (.08 n=2	.06 (.06 n=4	.09 (.08 n=3	3.56 (5.36 n=5	.46 (.51 n=3	.31 (.36 n=4	.64 (.20 n=2	.45 (.45 r-6	.18 (.27 n=4	.02 (.03) n=2
20m, N=37 $\bar{x}=.61$ SD=1.93	.07 (.04 n=2	.00 (.00 n=1	.04 (.05 n=2	.06 (.10 n=4	.05 (.06 n=3	3.12 (4.84 IF5	.47 (.61 n=3	.25 (.30 n=4	.70 (.33 n=2	.29 (.41 n=5	.26 (.34 n=4	.02 (.03) n=2
25m, N=34 $\bar{x}=.46$ SD=1.11	.15 (.11 n=2	.00 (.00 n=1	.00 (.00 n=1	.23 (.04 n=3	.03 (.04 n=3	2.36 (2.58 n=4	.66 (.82 n=3	.22 (.38 n=4	.74 (.62 n=2	.11 (.14 n=5	.18 (.33 n=4	.02 (.03) n=2
30m, N=35 $\bar{x}=.49$ SD=1.32	.04 (.05 n=2	.00 (.00 n=1	.11 (.00 n=1	.04 (.02 n=3	.14 (.05 n=3	11.14 (3.30 n=4	.98 (.27 n=4	1.60 (.53 n=4	1.07 (.19 n=2	1.03 (.23 n=5	.87 (.35 n=4	.00 (.00) n=2

Table F8. Monthly average density (N/L) of Diaptomus in the Rexford area of Libby Reservoir at discrete depths, 1983 through 1987. Values in parentheses are the standard deviations. For entire population:  $\bar{x}$ =2.16, SD=4.26, N=328.

Depth	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Surface, N=38 $\bar{x}$ = .74 SD=4.05	1.19 (.69 n=2	1.64 .00 n=1	.45 .36 n=3	.18 .26 n=4	.23 .14 n=3	7.92 8.64 n=5	.41 .27 n=3	1.26 .76 n=4	.35 .28 n=2	1.62 1.66 n=5	1.04 .52 n=4	.30 .16) n=2
3m, N=37 $\bar{x}$ =4.05 SD=7.95	5.31 (3.60 n=2	2.10 .00 n=1	1.81 .99 n=2	1.14 1.16 n=4	1.88 1.29 n=3	5.34 4.53 n=5	2.73 .90 n=3	4.44 2.16 n=4	24.40 24.30 n=2	2.92 2.55 n=5	1.51 .79 n=4	.64 .11) n=2
6m, N=37 $\bar{x}$ =3.75 SD=6.01	3.20 (2.20 n=2	2.53 .00 n=1	4.51 1.13 n=2	1.21 1.28 n=4	1.98 1.62 n=3	3.81 3.76 n=5	2.81 1.25 n=3	6.31 3.60 n=4	18.24 17.87 n=2	2.42 1.44 n=5	1.95 1.20 n=4	.50 .11) n=2
9m, N=36 $\bar{x}$ =2.50 SD=3.92	2.10 (2.03 n=2	1.92 .00 n=1	2.14 1.64 n=2	.66 .59 n=4	1.52 1.11 n=3	2.04 1.76 n=5	2.92 2.49 n=3	3.47 2.92 n=4	11.94 11.07 n=2	2.05 1.49 n=4	1.76 1.56 n=4	.18 .04) n=2
12m, N=37 $\bar{x}$ =1.85 SD=2.60	1.52 (1.41 n=2	.71 .00 n=1	2.81 2.06 n=2	.44 .31 n=4	1.34 1.22 n=3	1.30 .80 n=5	.56 .65 n=3	3.03 3.34 n=4	6.90 6.30 n=2	1.87 1.82 n=5	2.22 1.48 n=4	.43 .18) n=2
15m, N=37 $\bar{x}$ =1.60 SD=2.05	.94 (.79 n=2	.28 .00 n=1	2.51 2.26 n=2	.54 .44 n=4	1.09 1.18 n=3	.92 .81 n=5	.98 .90 n=3	2.50 1.82 n=4	5.29 4.59 n=2	1.78 1.49 n=5	2.24 2.14 n=4	.27 0 † n=2
20m, N=37 $\bar{x}$ =1.48 SD=1.85	.99 (.42 n=2	.82 .00 n=1	1.36 1.11 n=2	.38 .34 n=4	.69 .80 n=3	.96 .79 n=5	.66 .45 n=3	1.94 1.20 n=4	4.28 3.95 n=2	2.18 2.05 n=5	2.63 2.36 n=4	.52 0 † n=2
25m, N=34 $\bar{x}$ =1.23 SD=1.80	1.26 (1.01 n=2	.75 .00 n=1	.21 .00 n=1	.03 .03 n=3	.58 .65 n=3	.67 .50 n=4	.71 .56 n=3	1.39 .96 n=4	3.60 3.23 n=2	1.85 2.35 n=5	2.18 2.52 n=4	.41 .09) n=2
30m, N=35 $\bar{x}$ =1.11 SD=1.81	1.25 (.79 n=2	.00 .00 n=1	.07 .00 n=1	.05 .07 n=3	.50 .61 n=3	1.14 1.36 n=4	.45 .38 n=4	1.22 .64 n=4	3.25 3.08 n=2	1.01 .67 n=5	2.79 3.59 n=4	.32 .07) n=2

Table F9. monthly average density (N/L) of Cyclops in the Rexford area of Libby Reservoir at discrete depths, 1983 through 1987. Values in parentheses are the standard deviations. For entire population:  $\bar{x}=5.06$ ,  $SD=7.87$ ,  $N=328$ .

Depth	Jan N=4	Feb	Mar N=2	Apr N=3	May N=4	Jun N=4	Jul N=5	Aug N=3	Sep N=4	Oct N=5	Nov N=3	Dec N=4
Surface, N=8 $\bar{x}=3.39$ $SD=5.34$	.83 (.89 n=2	1.67 .00 n=1	.35 .32 n=3	.09 .09 n=4	1.89 .99 n=3	12.55 9.52 n=5	4.57 6.52 n=3	2.82 2.26 n=4	1.49 .02 n=2	3.11 3.09 n=5	2.48 1.83 n=4	1.07 (.05) n=2
3m, N=37 $\bar{x}=9.07$ $SD=12.39$	3.16 (.47 n=2	1.89 .00 n=1	1.75 .21 n=2	6.09 8.37 n=4	15.11 10.73 n=3	25.57 23.83 n=5	13.15 9.73 n=3	11.30 9.1 n=4	8.10 4.95 n=2	2.59 1.55 n=5	2.06 .89 n=4	2.26 (.03) n=2
6m, N=37 $\bar{x}=8.58$ $SD=10.93$	1.94 (.47 n=2	3.24 .00 n=1	5.70 2.06 n=2	10.10 15.39 n=4	16.19 13.36 n=3	20.57 19.27 n=5	10.17 2.67 n=3	9.65 8.70 n=4	6.30 2.12 n=2	2.51 1.31 n=5	2.33 1.12 n=4	1.92 (.35) n=2
9m, N=36 $\bar{x}=6.38$ $SD=8.60$	.93 (.95 n=2	2.35 .00 n=1	2.24 .19 n=2	8.26 9.07 n=4	10.63 10.83 n=3	14.1 17.96 n=5	8.61 3.06 n=3	6.26 4.12 n=4	5.60 .38 n=2	2.31 1.44 n=5	2.21 1.36 n=4	1.21 (.50) n=2
12m, N=37 $\bar{x}=4.80$ $SD=7.41$	.90 (.47 n=2	.89 .00 n=1	2.38 .64 n=2	2.43 2.80 n=4	9.16 9.89 n=3	14.59 15.77 n=5	2.11 2.28 n=3	4.27 2.1.1 n=4	5.30 .99 n=2	2.28 2.29 n=5	2.73 1.50 n=4	1.82 (.91) n=2
15m, N=37 $\bar{x}=3.92$ $SD=5.51$	.60 (.19 n=2	.43 .00 n=1	1.46 .35 n=2	2.82 3.43 n=4	8.00 10.05 n=3	9.95 11.10 n=5	2.75 1.48 n=3	3.26 1.25 n=4	4.55 .90 n=2	2.16 1.83 n=5	2.93 2.16 n=4	1.27 (1.08) n=2
20m, N=37 $\bar{x}=4.49$ $SD=4.77$	1.28 (1.06 n=2	.89 .00 n=1	1.10 .19 n=2	2.79 4.74 n=4	4.36 6.28 n=3	9.27 10.12 n=5	2.57 .88 n=3	3.08 1.67 n=4	3.69 1.25 n=2	2.23 2.11 n=5	2.82 2.07 n=4	1.46 (.71) n=2
25m, N=34 $\bar{x}=2.94$ $SD=3.96$	.76 (3.96 n=2	.64 .01 n=1	.75 .00 n=1	.34 .45 n=3	4.26 6.10 n=3	8.84 7.69 n=4	1.91 .97 n=3	3.1 2.56 n=4	2.75 .54 n=2	1.95 2.22 n=5	2.92 2.91 n=4	1.50 (.04) n=2
30m, N=35 $\bar{x}=2.73$ $SD=4.49$	.95 (.64 n=2	.00 .00 n=1	.28 .00 n=1	.24 .41 n=3	4.20 6.50 n=3	8.18 10.99 n=4	4.59 .68 n=4	2.80 2.12 n=4	2.22 .69 n=2	1.54 1.08 n=5	3.23 3.65 n=4	2.30 (.28) n=2

Table F10. Monthly average density (N/L) of *Epischura* in the Rexford area of Libby Reservoir at discrete depths, 1983 through 1987. Values in parentheses are the standard deviations. For entire population:  $\bar{x}$ =.01, SD=.04, N=338.

Depth	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Surface, N=38 $\bar{x}$ =.001 SD=.007	(.00 n=2	.00 n=1	.00 n=3	.00 n=4	.00 n=3	.00 n=5	.00 n=3	.01 n=4	.00 n=2	.00 n=5	.00 n=4	.00 n=2
3m, N=37 $\bar{x}$ =.02 5.06	(.00 n=2	.00 n=1	.00 n=2	.00 n=4	.01 n=3	.02 n=5	.01 n=3	.12 n=4	.04 n=2	.02 n=5	.00 n=4	.02 n=2
6m, N=37 $\bar{x}$ =.02 5.04	(.03 n=2	.00 n=1	.00 n=2	.00 n=4	.00 n=3	.00 n=5	.07 n=3	.08 n=4	.05 n=2	.01 n=5	.00 n=4	.00 n=2
9m, N=36 $\bar{x}$ =.03 SD=.06	(.00 n=2	.00 n=1	.00 n=2	.00 n=4	.00 n=3	.03 n=5	.11 n=3	.10 n=4	.00 n=2	.01 n=4	.01 n=4	.00 n=2
12m, N=37 $\bar{x}$ =.02 5.06	(.00 n=2	.00 n=1	.00 n=2	.00 n=4	.00 n=3	.01 n=5	.02 n=3	.11 n=4	.12 n=2	.01 n=5	.00 n=4	.00 n=2
15m, N=37 $\bar{x}$ =.01 5.03	(.00 n=2	.00 n=1	.00 n=2	.00 n=4	.00 n=3	.00 n=5	.01 n=3	.05 n=4	.12 n=2	.01 n=5	.00 n=4	.02 n=2
20m, N=37 $\bar{x}$ =.01 5.02	(.00 n=2	.00 n=1	.00 n=2	.00 n=4	.00 n=3	.01 n=5	.02 n=3	.05 n=4	.02 n=2	.01 n=5	.01 n=4	.02 n=2
25m, N=34 $\bar{x}$ =.01 SD=.02	(.00 n=2	.00 n=1	.00 n=1	.00 n=3	.00 n=3	.00 n=4	.02 n=3	.02 n=4	.00 n=2	.01 n=5	.00 n=4	.04 n=2
30m, N=35 $\bar{x}$ =.01 5.02	(.00 n=2	.00 n=1	.00 n=1	.00 n=3	.00 n=3	.00 n=4	.02 n=4	.02 n=4	.02 n=2	.01 n=5	.00 n=4	.00 n=2

Table F11. Monthly average density (N/L) of *Daphnia* in the Canada area of Libby Reservoir at discrete depths, 1983 through 1987. Values in parentheses are the standard deviations. For entire population:  $\bar{x}=4.14$ ,  $SD=11.38$ ,  $N=179$ .

Depth	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Surface, N=21 $\bar{x}=2.64$ $SD=7.99$						2.09 (2.67 n=2	12.91 20.77 n=3	1.07 2.27 n=5	.20 .38 n=4	.67 .76 n=4	1.24 1.95) n=3	
3m, N=21 $\bar{x}=18.28$ $SD=27.96$						83.45 (6.72 n=2	36.49 42.14 n=3	10.91 2.78 n=5	7.82 6.30 n=4	3.47 3.38 n=4	2.59 4.45) n=3	
6m, N=21 $\bar{x}=6.33$ $SD=3.96$						9.35 (6.58 n=2	10.07 3.25 n=3	8.07 1.63 n=5	4.64 3.45 n=4	4.48 3.13 n=4	2.39 3.61) 1s3	
9m, N=21 $\bar{x}=3.64$ $SD=3.10$						2.52 (1.34 n=2	7.83 3.74 n=3	4.14 2.02 n=5	3.00 3.04 n=4	1.60 1.61 n=4	2.11 3.51) n=3	
12m, N=20 $\bar{x}=2.57$ $SD=2.76$						2.47 (1.79 n=2	5.37 .49 n=3	3.23 4.71 n=5	1.68 .96 n=4	1.22 .19 n=3	1.30 2.26) n=3	
15m, N=20 $\bar{x}=1.86$ $SD=1.98$						2.45 (1.16 n=2	3.00 1.73 n=3	2.93 3.08 n=5	1.15 .91 n=4	.38 .36 n=3	.96 1.66) n=3	
20m, N=19 $\bar{x}=1.24$ $SD=1.38$						.00 (.00 n=2	.55 .49 n=3	.50 .48 n=5	.12 .21 n=3	.00 .00 n=3	.00 .00) n=3	
25m, N=18 $\bar{x}=0.01$ $SD=0.03$						.00 (.00 n=2	.00 .00 n=3	.00 .00 n=5	.05 .08 n=3	.00 .00 n=3	.00 0.00) n=3	
30m, N=18 $\bar{x}=0.000$ $SD=0.000$						.00 (.00 n=2	.00 .00 n=2	.00 .00 n=5	.00 .00 n=3	.00 .00 n=3	.00 .00) n=3	

Table F12. Monthly average density (N/L) of Bosmina in the Canada area of Libby Reservoir at discrete depths, 1983 through 1987. Values in parentheses are the standard deviations. For entire population:  $\bar{x}=27$ ,  $SD=1.05$ ,  $N=179$ .

Depth	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Surface, N=21 $\bar{x}=.14$ 5.39						.10 (.14 n=2	.01 .02 n=3	.03 .03 n=5	.45 .90 n=4	.09 .10 n=4	.09 .11) n=3	
3m, N=21 $\bar{x}=.56$ SD=2.03						.07 (.09 n=2	.05 .04 n=3	.18 .26 n=5	2.45 4.63 n=4	.17 .17 n=4	.05 .06) n=3	
6m, N=21 $\bar{x}=.57$ SD=1.87						.05 (.07 n=2	.06 .06 n=3	.32 .64 n=5	2.25 4.23 n=4	.25 .23 n=4	.06 .02) n=3	
9m, N=21 $\bar{x}=.38$ SD=.79						.03 (NA n=2	.00 .00 n=3	.41 .60 n=5	1.06 1.63 n=4	.30 .36 IF4	.12 .11) n=3	
12m, N=21 $\bar{x}=.48$ 5.95						.05 (.07 n=2	.02 .04 n=3	.20 .28 n=5	1.41 1.56 n=4	.83 1.38 n=4	.06 .10) n=3	
15m, N=21 $\bar{x}=.18$ SD=.32						.02 (.02 n=2	.01 .02 n=3	.11 .07 n=5	.35 .50 n=4	.33 .52 n=3	.23 .39) n=3	
20m, N=19 $\bar{x}=.02$ 5.05						.00 (.00 n=2	.02 .04 n=3	.06 .09 n=5	.01 .02 n=3	.00 .00 n=3	.00 .00) n=3	
25m, N=18 $\bar{x}=.00$ SD=.00						.00 (.00 n=2	.00 .00 n=2	.00 .00 n=5	.00 .00 n=3	.00 .00 rF3	.00 .00) n=3	
30m, N=18 $\bar{x}=.00$ SD=.00						.00 (.00 n=2	.00 .00 n=2	.00 .00 n=5	.00 .00 n=3	.00 .00 n=3	.00 .00) n=3	

Table F13. Monthly average density (N/L) of Diaptomus in the Canada area of Libby Reservoir at discrete depths, 1983 through 1987. Values in parentheses are the standard deviations. For entire population:  $\bar{x}$ =2.65, SD=5.13, N=179.

Depth	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Surface, N=21 $\bar{x}$ =3.40 SD=6.68						10.22 (14.40 n=2	9.54 13.57 n=3	.54 .57 n=5	.85 .87 n=4	2.83 2.57 n=4	1.6 2.10) n=3	
3m, N=21 $\bar{x}$ =6.88 SD=9.25						11.90 (14.71 n=2	12.49 16.38 n=3	3.94 4.71 n=5	11.90 11.47 n=4	2.25 1.66 n=4	2.31 3.73) n=3	
6m, N=21 $\bar{x}$ =4.23 SD=4.73						4.32 ( 5.82 n=2	3.31 1.74 n=3	3.80 3.48 n=5	8.16 8.62 n=4	3.43 3.33 n=4	1.61 2.62) n=3	
9m, N=21 $\bar{x}$ =3.03 SD=3.60						1.92 ( 2.57 n=2	3.40 2.84 n=3	4.16 5.74 n=5	4.56 4.06 n=4	1.42 1.47 n=4	1.65 2.67) n=3	
12m, N=20 $\bar{x}$ =2.68 SD=3.80						1.77 ( 2.31 n=2	3.43 3.02 n=3	4.00 7.07 n=5	2.87 2.41 n=4	1.50 1.27 n=3	.81 1.40) n=3	
15m, N=20 $\bar{x}$ =2.22 s3.95						1.55 ( 2.09 n=2	1.99 .97 n=3	4.16 7.82 n=5	2.18 1.33 n=4	1.18 2.00 n=3	.75 1.29) n=3	
20m, N=19 $\bar{x}$ =.46 SD=.91						.00 ( .00 n=2	1.45 1.44 n=3	.66 1.14 n=5	.38 .66 n=3	.00 .00 n=3	.00 .00) n=3	
25m, N=18 $\bar{x}$ =.02 SD=.07						.00 ( .00 n=2	.00 .00 n=2	.00 .00 n=5	.09 .16 n=3	.00 .00 n=3	.00 1.00) n=3	
30m, N=18 $\bar{x}$ =.00 SD=.00						.00 ( .00 n=2	.00 .00 n=2	.00 .00 n=5	.00 .00 n=3	.00 .00 n=3	.00 .00) n=3	

Table F14. Monthly average density (N/L) of Cyclops in the Canada area of Libby Reservoir at discrete depths, 1983 through 1987. Values in parentheses are the standard deviations. For entire population:  $\bar{x}=4.23$ ,  $SD=6.72$ ,  $N=179$ .

Depth	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Surface, N=21 $\bar{x}=3.75$ 935.82						4.43 ( 4.81 n=2	9.88 12.94 rF3	1.86 2.70 n=5	2.22 2.62 n=4	4.49 5.88 n=4	1.36 1.69 n=3	
3m, N=21 $\bar{x}=13.28$ SD=						26.95 (11.38 n=2	16.38 11.82 n=3	12.23 9.69 n=5	18.15 14.61 n=4	8.60 8.52 n=4	2.57 4.16 rF3	
6m, N=21 $\bar{x}=7.43$ ax. 89						12.84 (11.97 n=2	7.23 1.06 IF3	7.02 4.51 n=5	7.48 4.32 n=4	9.73 12.13 n=4	1.61 2.67 n=3	
9m, N=21 $\bar{x}=4.48$ SD=3.98						4.25 ( 4.12 n=2	5.04 2.23 n=3	6.12 6.1 n=5	4.74 3.27 n=4	3.92 4.42 n=4	1.74 2.51 n=3	
12m, N=20 $\bar{x}=3.89$ SD=4.56						4.44 ( 3.87 n=2	4.05 1.25 n=3	5.84 8.30 n=5	3.17 1.94 n=4	3.98 4.30 n=3	.96 1.66 n=3	
15m, N=20 $\bar{x}=2.80$ SD=3.18						5.17 ( 5.37 n=2	2.72 .94 n=3	4.87 4.87 n=5	2.30 2.30 n=4	.83 .83 n=3	.52 .52 n=3	
20m, N=19 $\bar{x}=1.78$ SD=1.47						.00 ( .00 n=2	2.01 2.33 n=3	1.63 1.84 n=5	.24 .41 n=3	.00 .00 n=3	.00 .00 n=3	
25m, N=18 $\bar{x}=1.02$ SD=.08						.00 ( .00 n=2	.00 .00 n=2	.00 .00 n=5	.11 .18 n=3	.00 .00 n=3	.00 .00 rF3	
30m, N=18 $\bar{x}=1.00$ SD=.00						.00 ( .00 n=2	.00 .00 n=2	.00 .00 n=5	.00 .00 n=3	.00 .00 n=3	.00 .00 n=3	

Table F15. Monthly average density (N/L) of *Epischura* in the Canada area of Libby Reservoir at discrete depths, 1983 through 1987. Values in parentheses are the standard deviations. For entire population:  $\bar{x}=0.4$ ,  $SD=.18$ ,  $N=179$ .

Depth	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Surface, N=21 $\bar{x}=.01$ $SD=.03$						.00 (.00 n=2	.00 (.00 n=3	.01 (.02 n=5	.00 (.00 n=4	.05 (.05 n=4	.00 (.00 n=3	
3m, N=21 $\bar{x}=.06$ $SD=.10$						.17 (.23 n=2	.02 (.04 n=3	.12 (.14 n=5	.07 (.06 n=4	.02 (.04 n=4	.01 (.01 n=3	
6m, N=21 $\bar{x}=.04$ $SD=.07$						.04 (.05 n=2	.00 (.00 n=3	.12 (.09 n=5	.05 (.08 n=4	.01 (.02 n=4	.00 (.00 n=3	
9m, N=21 $\bar{x}=.16$ $SD=.48$						1.12 (1.54 n=2	.00 (.00 n=3	.19 (.17 n=5	.05 (.07 n=4	.02 (.04 n=4	.00 (.00 n=3	
12m, N=20 $\bar{x}=.04$ $SD=.09$						.00 (.00 n=2	.00 (.00 n=3	.13 (.16 n=5	.04 (.05 n=4	.02 (.04 n=3	.00 (.00 n=3	
15m, N=20 $\bar{x}=.02$ $SD=.03$						.00 (.00 n=2	.01 (.02 n=3	.05 (.06 n=5	.01 (.02 n=4	.00 (.00 Is3	.00 (.00 n=3	
20m, N=19 $\bar{x}=.004$ $SD=.02$						.00 (.00 n=2	.00 (.00 n=3	.00 (.00 n=5	.02 (.04 n=3	.00 (.00 rF3	.00 (.00 n=3	
25m, N=18 $\bar{x}=.00$ $SD=.00$						.00 (.00 n=2	.00 (.00 n=2	.00 (.00 n=5	.00 (.00 n=3	.00 (.00 n=3	.00 (.00 n=3	
30m, N=18 $\bar{x}=.00$ $SD=.00$						.00 (.00 n=2	.00 (.00 n=2	.00 (.00 n=5	.00 (.00 n=3	.00 (.00 n=3	.00 (.00 n=3	

**APPENDIX G**  
Tables **G1** through **G13**

Nearshore **floating and** sinking gill net catches  
in three **sampling** areas of Libby Reservoir, 1983 **through** 1987.

Table G1. Sinking gill net catches of fish in the Rexford area of Libby Reservoir in the spring.

Date	(N) <sup>a/</sup>	RB	WCT	HB	Total Trout	DV	KOK	MAF	CRC	NSQ	RSS	CSU	FSU	YP	LING	
June 1984	(17)	4	9	1	12	62	32	0	55	1172	149	44	530	97	14	4
June 1985	(21)	7	2	3	12	30	9	19	1776	195	28	470	98	21	12	
May 1986	(28)	6	0	1	7	53	0	161	1097	153	3	232	43	73	19	
May 1987	(23)	12	3	10	25	30	17	63	715	239	7	234	49	154	24	

<sup>a/</sup> n=number of nets

Table G2. Floating gill net catches of fish in the Temile area of Libby Reservoir by date.

Date	(N) <sup>a/</sup>	RB	WCT	HB	Total Trout	DV	KOK	MAF	CRC	NEQ	RSS	CSU	FSU	YP
June 1983	(1)	6	2	1	9	2	1	0	0	0	0	0	0	0
July 1983	(12)	32	11	6	49	0	0	0	4 6 4	3 6	14	51	0	0
Aug. 1983	(11)	7	1	2	10	0	0	0	5%	70	14	82	0	0
Sep. 1983	(14)	26	11	24	61	0	0	4	218	17	2	2	0	0
Oct. 1983	(10)	29	10	26	65	0	2	4	21	11	2	3	0	0
Nov. 1983	(10)	27	7	35	69	1	1	0	24	5	1	4	0	0
Dec. 1983	(10)	11	13	17	41	0	2	0	2	1	0	0	0	0
1983 Total	(68)	138	55	111	304	3	6	8	1285	196	33	92	0	0
Jan. 1984	(8)	2	3	7	12	0	1	0		10	0	0	0	0
Feb. 1984	(9)	10	5	4	19	1	1	0		10	0	1	0	0
Mar. 1984	(11)	18	3	9	30	1	2	0		10	0	0	0	0
Apr. 1984	(10)	47	40	20	107	2	54	4	28	4	0	9	0	0
May 1984	(10)	64	38	27	129	1	9	1	177	11	0	3	0	0
Jul. 1984	(9)	63	7	19	89	4	3	1	965	13	11	8	0	0
Aug. 1984	(18)	7	2	6	15	0	1	0	554	105	32	62	0	0
Sep. 1984	(14)	33	10	5	48	1	45	15	128	17	1	10	0	0
Nov. 1984	(19)	36	11	15	62	10	16	0	164	3	0	1	0	1
1984 Total	(108)	280	119	112	511	20	132	21	2019	152	44	94	0	1
May 1985	(10)	35	13	8	56	6	34	0	380	8	0	3	0	0
Aug. 1985	(16)	10	0	8	18	0	2	0	4 5 4	2 2	11	4	0	0
Oct. 1985	(19)	27	10	9	46	1	82	4	160	12	1	7	0	0
1985 Total	(45)	72	23	25	120	7	118	4	334	31	3	8	0	0
Apr. 1986	(24)	27	3	29	59	4	77	0	147	0	0	1	0	0
Sep. 1986	(28)	43	16	40	93	0	59	17	600	32	3	12	1	3
1986 Total	(52)	70	19	69	158	4	136	17	747	32	3	13	0	3
Sep. 1987	(28)	34	8	39	81	0	172	0	1205	41	11	4	0	0

<sup>a/</sup> n=number of nets

Table G3. Floating gill net catches (# fish/net) in the Tennile area of Libby Reservoir by date.

Date	(N) <sup>a/</sup>	RB	WCT	HB	Total Trout	DV	KCK	MAF	CRC	NEQ	RSS	CSU	FSU	YP
June 1983	(1)	6.00	2.00	1.00	9.00	2.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
July 1983	(12)	2.67	0.92	0.50	4.08	0.00	0.00	0.00	38.70	3.00	1.20	4.30	0.00	0.00
Aug. 1983	(11)	0.64	0.09	0.18	0.91	0.00	0.00	0.00	50.50	6.40	1.30	7.50	0.00	0.00
Sep. 1983	(14)	1.86	0.79	1.71	4.36	0.00	0.00	0.29	15.60	1.20	0.07	0.14	0.00	0.00
Oct. 1983	(10)	2.90	1.00	2.60	6.50	0.00	0.20	0.40	2.10	1.10	0.20	0.30	0.00	0.00
Nov. 1983	(10)	2.70	0.70	3.50	6.90	0.10	0.10	0.00	2.40	0.50	0.10	0.40	0.00	0.00
Dec. 1983	(10)	1.10	1.30	1.70	4.10	0.00	0.20	0.00	0.20	0.10	0.00	0.00	0.00	0.00
1983 Total	(68)	2.03	0.81	1.63	4.47	0.04	0.09	0.12	18.90	2.90	0.49	1.35	0.00	0.00
Jan. 1984	(8)	0.25	0.38	0.88	1.50	0.00	0.12	0.00	0.12	0.00	0.00	0.00	0.00	0.00
Feb. 1984	(9)	1.11	0.56	0.44	2.11	0.11	0.11	0.00	0.11	0.00	0.00	0.11	0.00	0.00
Mar. 1984	(11)	1.64	0.27	0.82	2.73	0.09	0.18	0.00	0.09	0.00	0.00	0.00	0.00	0.00
Apr. 1984	(10)	4.70	4.00	2.00	10.70	0.20	5.40	0.40	2.80	0.40	0.00	0.90	0.00	0.00
May 1984	(10)	6.40	3.80	2.70	12.90	0.10	0.90	0.10	17.70	1.10	0.00	0.30	0.00	0.00
Jun. 1984	(9)	7.00	0.78	2.11	9.89	0.44	0.33	0.11	107.20	1.44	1.22	0.89	0.00	0.00
Aug. 1984	(18)	0.39	0.11	0.33	0.83	0.00	0.06	0.00	30.80	5.80	1.80	3.40	0.00	0.00
Sep. 1984	(14)	2.36	0.71	0.36	3.43	0.07	3.21	1.07	9.10	1.20	0.07	0.70	0.00	0.00
Nov. 1984	(19)	1.89	0.58	0.79	3.26	0.53	0.84	0.00	8.60	0.16	0.00	0.05	0.00	0.00
1984 Total	(108)	2.59	1.10	1.04	4.73	0.19	1.22	0.19	18.69	0.41	0.27	0.87	0.00	0.00
May 1985	(10)	3.50	1.30	0.80	5.60	0.60	3.40	0.00	38.00	0.80	0.00	0.30	0.00	0.00
Aug. 1985	(16)	0.62	0.00	0.50	1.12	0.00	0.12	0.00	28.40	1.40	0.70	0.40	0.00	0.00
Oct. 1985	(19)	1.42	0.53	0.47	2.42	0.05	4.32	0.21	8.40	0.60	0.05	0.40	0.00	0.00
1985 Total	(45)	1.60	0.51	0.56	2.67	0.16	2.62	0.09	22.10	0.93	0.27	0.31	0.00	0.00
Apr. 1986	(24)	1.12	0.12	1.21	2.46	0.17	3.21	0.00	6.10	0.00	0.00	0.04	0.00	0.00
Sep. 1986	(28)	1.54	0.57	1.43	3.54	0.00	2.11	0.61	21.40	1.14	0.11	0.43	0.10	0.11
1986 Total	(52)	1.35	0.37	1.33	3.04	0.08	2.62	0.33	14.40	0.62	0.06	0.25	0.02	0.06
Sep. 1987	(28)	1.21	0.29	1.39	2.89	0.00	6.14	0.00	43.04	1.46	0.39	0.14	0.00	0.00

<sup>a/</sup> number of nets

Table G4. Sinking gill net catches of fish in the Tannile area of Libby Reservoir by date.

Date	(N) <sup>a/</sup>	RB	WCT	HB	Total Trout	DV	KCK	MMF	CRG	NSQ	RSS	CSU	FSU
July 1983	(2)	6	0	0	6	0	0	15	32	5	2	8	5
Aug. 1983	(2)	11	1	1	13	0	0	9	15	2	1	40	6
Sep. 1983	(2)	10	3	0	11	0	0	6	15	9	2	36	0
Oct. 1983	(2)	3	0	0	3	1	0	8	6	13	0	19	0
Nov. 1983	(2)	2	0	0	2	2	0	0	25	12	0	16	0
Dec. 1983	(1)	1	1	0	2	0	0	3	19	9	0	6	0
1983 Total	(11)	33	3	1	37	3	0	41	112	50	5	125	11
Jan. 1984	(2)	3	0	1	4	1	0	1	9	1	0	3	3
Feb. 1984	(2)	4	0	0	4	1	0	4	4	0	0	10	2
Mar. 1984	(2)	2	0	1	3	3	0	2	10	4	0	16	2
Apr. 1984	(2)	0	0	0	0	2	1	9	28	2	0	8	0
May 1984	(2)	0	0	0	0	1	0	11	0	19	1	12	3
June 1984	(2)	1	0	0	1	0	0	0	0	4	0	26	13
Aug. 1984	(4)	3	0	0	3	1	0	8	20	7	0	34	6
Nov. 1984	(4)	2	0	0	2	5	2	4	9	11	0	30	4
1984 Total	(20)	15	0	2	17	14	3	42	80	48	1	139	33
Apr. 1985	(1)	0	0	0	0	0	0	0	7	0	0	0	0
May 1985	(2)	1	0	0	1	1	0	8	0	4	0	16	0
Aug. 1985	(2)	3	1	3	7	2	2	18	34	5	0	18	4
Oct. 1985	(2)	0	0	0	0	1	15	8	22	2	0	13	1
1985 Total	(7)	4	1	3	8	4	17	34	63	11	0	47	5
Apr. 1986	(4)	0	0	1	1	4	0	18	65	4	0	8	1
Sep. 1987	(4)	1	0	0	1	0	2	30	86	29	1	55	3

<sup>a/</sup> n=number of nets

Table G5. Sinking gill net catches (# fish/net) in the Tenmile area of Libby Reservoir by date.

Date	(N) <sup>a/</sup>	RB	WCT	HB	Total Trout	DV	KCK	MAF	CRC	NSQ	RSS	CSU	FSU	YP
July 1983	(2)	3.00	0.00	0.00	3.00	0.00	0.00	7.50	16.00	2.50	1.00	4.00	2.50	0.00
Aug. 1983	(2)	5.50	0.50	0.50	6.50	0.00	0.00	4.50	7.50	1.00	0.50	20.00	3.00	0.00
Sep. 1983	(2)	5.00	0.50	0.00	5.50	0.00	0.00	3.00	7.50	4.50	1.00	18.00	0.00	0.00
Oct. 1983	(2)	1.50	0.00	0.00	1.50	0.50	0.00	4.00	3.00	6.50	0.00	9.50	0.00	0.50
Nov. 1983	(2)	1.00	0.00	0.00	1.00	1.00	0.00	0.00	12.50	6.00	0.00	8.00	0.00	0.00
Dec. 1983	(1)	1.00	1.00	0.00	2.00	0.00	0.00	3.00	19.00	9.00	0.00	6.00	0.00	0.00
1983 Total	(11)	3.00	0.27	0.09	3.36	0.27	0.00	3.73	10.18	4.5	0.45	11.36	1.00	0.09
Jan. 1984	(2)	1.50	0.00	0.50	2.00	0.50	0.00	2.00	4.50	0.50	0.00	1.50	1.50	0.00
Feb. 1984	(2)	2.00	0.00	0.00	2.00	0.50	0.00	2.00	2.00	0.00	0.00	5.00	1.00	0.00
Mar. 1984	(2)	1.00	0.00	0.50	1.50	1.50	0.00	1.00	5.00	2.00	0.00	8.00	1.00	0.00
Apr. 1984	(2)	0.00	0.00	0.00	0.00	1.00	0.50	4.50	14.00	1.00	0.00	4.00	0.00	0.00
May 1984	(2)	0.00	0.00	0.00	0.00	0.50	0.00	5.50	0.00	9.50	0.50	6.00	1.50	0.00
June 1984	(2)	0.50	0.00	0.00	0.50	0.00	0.00	0.00	0.00	2.00	0.00	13.00	6.50	0.00
Aug. 1984	(4)	0.75	0.00	0.00	0.75	0.25	0.00	2.00	5.00	1.75	0.00	8.50	1.50	0.00
Nov. 1984	(4)	0.50	0.00	0.00	0.50	1.25	0.50	1.00	2.25	2.75	0.00	7.50	1.00	0.25
1984 Total	(20)	0.75	0.00	0.10	0.85	0.70	0.15	2.10	4.00	2.40	0.05	6.95	1.65	0.05
Apr. 1985	(1)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.00	0.00	0.00	0.00	0.00	0.00
May 1985	(2)	0.50	0.00	0.00	0.50	0.50	0.00	4.00	0.00	2.00	0.00	8.00	0.00	1.00
Aug. 1985	(2)	1.50	0.50	1.50	3.50	1.00	1.00	9.00	17.00	2.50	0.00	9.00	2.00	1.00
Oct. 1985	(2)	0.00	0.00	0.00	0.00	0.50	7.50	4.00	11.00	1.00	0.00	6.50	0.50	0.00
1985 Total	(7)	0.57	0.14	0.43	1.14	0.57	2.43	4.86	9.00	1.57	0.00	6.71	0.71	0.57
Apr. 1986	(4)	0.00	0.00	0.25	0.25	1.00	0.00	4.50	16.25	1.00	0.00	2.00	0.25	0.00
Sep. 1987	(4)	0.25	0.00	0.00	0.25	0.00	0.50	7.50	21.50	7.25	0.25	13.75	0.75	1.00

<sup>a/</sup> number of nets

Table G6. Floating gill net catches of fish in the Rexford area of Libby Reservoir by date.

Date	(N) <sup>a/</sup>	RB	WCT	HB	Total Trout	DV	KCK	MWF	CRC	NSQ	RSS	CSU	FSU	YP		
July 1983 (10)	2	6	1	17	44	1	0	0	572	53	29	78	0	0		
Aug. 1983 (14)	124	27	16	167	0	0	2	657	88	31	60	1	1			
Sep. 1983 (10)	19	4	15	38	0	6	5	132	28	15	6	0	0	0		
at. 1983 (10)	25	8	18	51	1	1	8	41	13	2	0	0	0	0		
Nov. 1983 (10)	37	26	33	96	2	1	0	19	7	0	3	0	0	0		
1983 Total (54)	231	66	99	3 %	4	8	15	1421	189	77	147	1	1	1		
Jan. 1984 (1)	3	5	0	8	2	22	1	0	0	0	0	0	0	0		
Feb. 1984 (13)	31	27	21	79	0	23	2	2	0	0	2	0	0	0		
Mar. 1984 (8)	51	22	35	108	0	13	2	10	4	0	22	0	0	0		
Apr. 1984 (6)	67	49	38	154	12	33	12	558	30	0	10	0	0	0		
May 1984 (4)	51	39	20	110	13	15	1	126	8	2	9	0	0	0		
June 1984 (2)	13	5	3	21	0	0	0	144	13	6	3	0	0	0		
Aug. 1984 (18)	32	3	11	46	0	1	1	910	98	43	28	0	0	0		
Sep. 1984 (13)	5	8	6	19	2	108	8	167	13	5	5	0	0	0		
Nov. 1984 (18)	20	16	21	57	17	26	4	51	8	0	0	0	0	0		
1984 Total (83)	273	174	155	602	46	241	31	1968	174	56	135	0	3	3		
Apr. 1985 (10)	81	35	48	164	9	15	8	4	9	3	51	1	35	0	0	
June 1985 (10)	42	9	22	73	10	30	4	7	2	7	48	19	46	1	0	
Aug. 1985 (22)	25	10	11	46	0	13	11	1216	60	32	57	0	0	0	0	
Oct. 1985 (19)	71	25	31	127	8	235	3	85	12	2	1	0	0	0	0	
1985 Total (61)	219	79	112	410	27	293	26	3	5	2	7	171	54	139	1	11
Sep. 1986 (30)	70	20	53	143	5	146	32	431	55	11	1	0	0	0	0	
Sep. 1987 (28)	8	5	7	20	0	160	5	1122	34	10	4	0	0	0	0	

<sup>a/</sup> number of nets

Table G7. Floating gill net catches (# fish/net) in the Rexford area of Libby Reservoir by date.

Date	(N) <sup>a/</sup>	RB	WCT	HB	Total Trout	DV	KCK	MF	CR	NSQ	RSS	CSU	FSU	YP
July 1983	(10)	2.60	0.10	1.70	4.40	0.10	0.00	0.00	5.72	5.30	2.90	7.80	0.00	0.00
Aug. 1983	(14)	8.86	1.93	1.14	11.93	0.00	0.00	0.14	46.96	6.30	2.20	4.30	0.07	0.00
Sep. 1983	(10)	1.90	0.40	1.50	3.80	0.00	0.60	0.50	13.20	2.80	1.50	0.60	0.00	0.00
Oct. 1983	(10)	2.50	0.80	1.80	5.10	0.10	0.10	0.80	4.10	1.30	0.20	0.00	0.00	0.10
Nov. 1983	(10)	3.70	2.60	3.30	9.60	0.20	0.10	0.00	1.90	0.70	0.00	0.30	0.00	0.00
1983 Total	(54)	4.28	1.22	1.83	7.33	0.07	0.15	0.28	2.48	1.17	0.33	0.44	0.02	0.02
Jan. 1984	(1)	3.00	5.00	0.00	8.00	2.00	22.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
Feb. 1984	(13)	2.38	2.11	1.62	6.08	0.00	1.77	0.15	0.15	0.00	0.00	0.15	0.00	0.00
Mar. 1984	(8)	6.33	2.75	4.38	13.50	0.00	1.62	0.25	1.12	0.50	0.00	2.80	0.00	0.00
Apr. 1984	(6)	11.17	8.17	6.33	25.67	2.00	5.50	2.00	93.00	5.00	0.00	1.70	0.00	0.00
May 1984	(4)	12.75	9.75	5.00	27.50	3.25	3.75	0.25	31.50	2.00	0.50	2.25	0.00	0.00
June 1984	(2)	6.50	2.50	1.50	10.50	0.00	0.00	0.00	72.00	6.50	3.00	1.50	0.00	0.00
Aug. 1984	(18)	1.78	0.17	0.61	2.56	0.00	0.06	0.06	2.78	1.17	0.44	0.67	0.00	0.11
Sep. 1984	(13)	0.38	0.62	0.46	1.46	0.15	8.31	0.62	5.08	0.46	0.08	0.15	0.00	0.08
Nov. 1984	(18)	1.11	0.89	1.17	3.17	0.94	1.44	0.22	2.83	0.44	0.00	0.00	0.00	0.00
1984 Total	(83)	3.29	2.10	1.87	7.25	0.5	2.90	0.37	3.25	0.64	0.13	0.40	0.00	0.04
Apr. 1985	(10)	8.10	3.50	4.80	16.40	0.90	1.50	0.80	49.90	5.10	0.10	3.50	0.00	0.00
June 1985	(10)	4.20	0.90	2.20	7.30	1.00	3.00	0.40	72.70	4.80	1.90	4.60	0.10	0.00
Aug. 1985	(22)	1.14	0.45	0.50	2.09	0.00	0.59	0.50	5.30	2.70	1.50	2.60	0.00	0.50
Oct. 1985	(19)	3.74	1.32	1.63	6.68	0.42	12.37	0.16	4.47	0.63	0.11	0.05	0.00	0.00
1985 Total	(61)	3.59	1.30	1.84	6.72	0.44	4.80	0.43	5.33	1.00	0.30	0.52	0.00	0.18
Sep. 1986	(30)	2.33	0.67	1.77	4.77	0.17	4.87	1.07	14.37	1.83	0.37	0.03	0.00	0.17
1986 Total	(30)	2.33	0.67	1.77	4.77	0.17	4.87	1.07	14.37	1.83	0.37	0.03	0.00	0.17
Sep. 1987	(28)	0.29	0.18	0.25	0.71	0.00	5.71	0.18	37.40	1.21	0.36	0.14	0.00	0.21
1987 Total	(28)	0.29	0.18	0.25	0.71	0.00	5.71	0.18	19.00	1.21	0.36	0.14	0.00	0.21

<sup>a/</sup> number of nets

Table G8. Sinking gill net catches of fish in the Rexford area of Libby Reservoir by date.

Date	(N) <sup>a/</sup>	RB	WCT	HB	Total Trout	DV	KCK	MMF	CRC	NSQ	RSS	CSU	FSU	YP
July 1983	(2)	4	0	2	6	2	0	2	30	3	0	12	1	1
Aug. 1983	(2)	6	0	1	7	0	0	0	0	0	0	3		11
Sep. 1983	(2)	0	0	1	1	1	1	7	18	11	0	25	3	3
Oct. 1983	(2)	5	0	0	5	2	0	12	32	3	0	26	1	1
Nov. 1983	(2)	2	1	2	5	2	0	1	100	28	0	13	1	1
1983 Total	(10)	17	1	6	24	7	1	22	180	45	0	79	7	1
Feb. 1984	(4)	14	2	9	25	7	0	29	17	1	0	18	3	3
Mar. 1984	(2)	3	0	0	3	3	0	28	28	5	0	13	2	2
Apr. 1984	(1)	0	0	0	0	1	3	0	0	0	0	10	0	0
June 1984	(1)	1	0	0	1	1	0	0	0	0	0	0	0	0
Aug. 1984	(4)	3	2	0	5	1	2	7	9	11	0	2	0	1
Nov. 1984	(3)	6	0	0	6	5	0	1	43	7	0	13	0	0
1984 Total	(15)	27	4	9	40	18	5	65	97	24	0	74	6	4
Apr. 1985	(2)	4	0	2	6	5	0	32	0	0	0	0	4	4
June 1985	(2)	0	0	0	0	0	3	0	0	0	5	0	0	0
Aug. 1985	(4)	2	0	1	3	0	0	8	61	7	0	10	0	0
Oct. 1985	(2)	5	1	0	6	3	2	7	54	11	1	9	0	0
1985 Total	(10)	11	1	3	15	8	5	47	115	18	6	19	4	2
Sep. 1987	(4)	1	0	0	1	0	0	18	80	23	0	27	1	1

<sup>a/</sup> number of nets

Table G9. Sinking gill net catches (# fish/net) in the Rexford area of Libby Reservoir by date.

Date	(N) <sup>a/</sup>	RB	WCT	HB	Total Trout	DV	KOK	MAF	CRC	NSQ	RSS	CSU	FSU	YH
July 1983	(2)	2.00	0.00	1.00	3.00	1.00	0.00	1.00	15.00	1.50	0.00	6.00	0.50	0.00
Aug. 1983	(2)	3.00	0.00	0.50	3.50	0.00	0.00	0.00	0.00	0.00	0.00	1.50	0.50	0.00
Sep. 1983	(2)	0.00	0.00	0.50	0.50	0.50	0.50	3.50	9.00	5.50	0.00	12.50	1.50	0.00
Oct. 1983	(2)	2.50	0.00	0.00	2.50	1.00	0.00	6.00	16.00	1.50	0.00	13.00	0.50	0.50
Nov. 1983	(2)	1.00	0.50	1.00	2.50	1.00	0.00	0.50	50.00	14.00	0.00	6.50	0.50	0.00
1983 Total	(10)	1.70	0.10	0.60	2.40	0.70	0.10	2.20	18.00	4.50	0.00	7.90	0.70	0.10
Feb. 1984	(4)	3.50	0.50	2.25	6.25	1.75	0.00	7.25	4.25	0.25	0.00	4.50	0.75	0.00
Mar. 1984	(2)	1.50	0.00	0.00	1.50	1.50	0.00	14.00	14.00	2.50	0.00	6.50	1.00	0.00
Apr. 1984	(1)	0.00	0.00	0.00	0.00	1.00	3.00	0.00	0.00	0.00	0.00	10.00	0.00	0.00
June 1984	(1)	1.00	0.00	0.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Aug. 1984	(4)	0.75	0.50	0.00	1.25	0.25	0.50	1.75	2.25	2.75	0.00	5.00	0.25	0.00
Nov. 1984	(3)	2.00	0.00	0.00	2.00	1.67	0.00	0.33	14.33	2.33	0.00	4.33	0.00	1.00
1984 Total	(15)	1.80	0.27	0.60	2.67	1.20	0.33	4.33	6.47	1.60	0.00	4.93	0.40	0.20
Apr. 1985	(2)	2.00	0.00	1.00	3.00	2.50	0.00	16.00	0.00	0.00	0.00	0.00	2.00	0.00
June 1985	(2)	0.00	0.00	0.00	0.00	0.00	1.50	0.00	0.00	0.00	2.50	0.00	0.00	1.50
Aug. 1985	(4)	0.50	0.00	0.25	0.75	0.00	0.00	2.00	15.25	1.75	0.00	2.50	0.00	4.00
Oct. 1985	(2)	2.50	0.50	0.00	3.00	1.50	1.00	3.50	27.00	5.50	0.50	4.50	0.00	2.00
1985 Total	(10)	1.10	0.10	0.30	1.50	0.80	0.50	4.70	11.50	1.80	0.60	1.90	0.40	2.00
Sep. 1987	(4)	0.25	0.00	0.00	0.25	0.00	0.00	4.50	20.00	5.75	0.00	6.75	0.25	4.00

<sup>a/</sup> n=number of nets

Table G10. Floating gill net catches of fish in the Canada area of Libby Reservoir by date.

Date	(N) <sup>a/</sup>	RB	WCT	HB	Total Trout	DV	KOK	MAF	CRG	NSQ	RSS	CSU	FSU	YP
July 1983 (8)	14	4	0	18	0	0	0	340	40	8	93	0	0	
Aug. 1983 (9)	4	0	0	4	0	1	0	239	149	13	61	0	0	
Sep. 1983 (14)	21	7	5	33	0	3	3	2 8 7	62	3	20	0	0	
Oct. 1983 (14)	24	24	25	73	2	3	4	11	14	0	28	0	0	
Nov. 1983 (8)	25	31	15	71	0	4	5	5	5	0	28	0	0	
1983 Total (53)	88	66	45	199	2	11	12	882	270	24	230	0	0	
Aug. 1984 (12)	8	0	3	11	0	0	2	851	232	15	61	0	0	
Sep. 1984 (14)	27	20	25	72	3	2 6 8	4	261	37	5	5	0	0	
Nov. 1984 (19)	41	42	27	110	4	110	5	12	8	0	65	0	0	
1984 Total (45)	76	62	55	193	7	3 7 8	11	1124	277	20	131	0	0	
Aug. 1985 (21)	25	8	10	4 3	0 5 0	2	594	77	4	45	0	0		
Oct. 1985 (9)	19	12	4	35	0	364	2	14	3	0	11	0	0	
1985 Total (30)	44	20	14	78	0	414	4	608	80	4	56	0	0	
Sep. 1986 (28)	48	20	26	94	1	204	1	1050	25	4	54	0	0	
Sep. 1987 (28)	59	8	17	84	2	2 2 4	3	1224	43	8	33	0	0	

<sup>a/</sup> n=number of nets

Table G11. Floating gill net catches (# fish/net) in the Canada area of Libby Reservoir by date.

Date	(N) <sup>a/</sup>	RB	WCT	HB	Total Trout	DV	KCK	MF	QC	NSQ	RSS	CSU	FSU	YP
July 1983	(8)	1.75	<b>0.50</b>	<b>0.00</b>	2.25	0.00	<b>0.00</b>	0.00	<b>42.50</b>	<b>5.00</b>	<b>1.00</b>	<b>11.60</b>	0.00	0.00
Aug. 1983	(9)	0.44	<b>0.00</b>	<b>0.00</b>	0.44	<b>0.00</b>	<b>0.11</b>	<b>0.00</b>	26.60	<b>16.60</b>	1.40	6.80	<b>0.00</b>	0.00
Sep. 1983	(14)	<b>1.50</b>	<b>0.50</b>	0.36	2.36	<b>0.00</b>	<b>0.21</b>	<b>0.21</b>	20.50	4.40	0.07	<b>1.40</b>	<b>0.00</b>	0.00
Oct. 1983	(14)	<b>1.71</b>	<b>1.71</b>	1.79	<b>5.21</b>	0.14	<b>0.21</b>	0.29	0.79	<b>1.00</b>	0.00	<b>2.00</b>	<b>0.00</b>	0.00
Nov. 1983	(8)	<b>3.12</b>	3.88	1.88	8.88	0.00	0.50	0.62	0.62	<b>0.62</b>	<b>0.00</b>	3.50	<b>0.00</b>	0.00
1983 Total	(53)	1.66	1.25	0.85	3.75	0.04	<b>0.21</b>	0.23	<b>16.64</b>	<b>5.09</b>	0.45	4.34	0.00	0.00
Aug. 1984	(12)	0.67	<b>0.00</b>	0.25	0.92	<b>0.00</b>	0.00	0.17	30.40	8.30	<b>0.50</b>	2.20	<b>0.00</b>	0.00
Sep. 1984	(14)	1.93	1.43	1.79	5.14	<b>0.21</b>	<b>19.14</b>	0.29	<b>18.60</b>	2.60	0.40	0.40	0.00	0.00
Nov. 1984	(19)	2.16	<b>2.21</b>	1.42	5.79	<b>0.21</b>	5.79	0.26	0.63	0.42	<b>0.00</b>	3.42	0.00	0.00
1984 Total	(45)	1.69	1.38	1.22	4.29	0.16	8.40	0.24	24.98	<b>6.16</b>	0.44	2.91	<b>0.00</b>	0.00
Aug. 1985	(21)	<b>1.19</b>	0.38	0.48	<b>2.05</b>	0.00	2.38	<b>0.10</b>	28.30	3.70	0.20	<b>2.10</b>	<b>0.00</b>	0.00
Oct. 1985	(9)	<b>2.11</b>	1.33	0.44	3.89	0.00	85.30	0.22	<b>1.60</b>	0.30	<b>0.00</b>	1.20	<b>0.00</b>	0.00
1985 Total	(30)	1.47	0.67	0.47	<b>2.60</b>	<b>0.00</b>	<b>13.80</b>	<b>0.13</b>	20.27	2.67	<b>0.13</b>	1.87	<b>0.00</b>	0.00
Sep. 1986	(28)	<b>1.71</b>	<b>0.71</b>	0.93	3.36	0.04	7.29	0.04	<b>37.50</b>	0.89	0.14	1.93	<b>0.00</b>	0.00
Sep. 1987	(28)	<b>2.11</b>	0.29	<b>0.61</b>	3.00	0.07	8.00	<b>0.11</b>	43.70	1.54	0.29	<b>1.18</b>	<b>0.00</b>	0.00

<sup>a/</sup> n=number of nets

Table G12. Sinking gill net catches of fish in the Canada area of Libby Reservoir by date.

Date	(N) <sup>a/</sup>	RB	WCT	HB	Total Trout	DV	KCK	MMF	CRC	NSQ	RSS	CSU	FSU	YP	
July 1983	(2)	0	0	0	0	1	0	1	19	2	0	15	0	0	
Aug. 1983	(2)	2	2	0	4	0	0	4	19	11	1	40	1	1	
Sep. 1983	(2)	1	0	1	2	1	3	14	35	7	1	9	2	1	
Oct. 1983	(2)	3	0	2	5	1	1	11	5	6	1	16	1	1	
Nov. 1983	(2)	4	0	0	4	3	0	23	10	4	0	3	0	0	
1983 Total	(10)	10	2	3	15	6	4	53	88	30	3	8	3	3	0
Aug. 1984	(4)	2	2	3	8	0	6	16	53	11	1	290		0	
Nov. 1984	(4)	2	3	3	12	2	11	45	3	4	0	9	1	1	
1984 Total	(8)	4	5					61	56	15	1	3	8	1	0
Aug. 1985	(2)	1	0	0	1	0	2	14	15	2	0	5	0	0	
Sep. 1987	(4)	15	0	1	16	0	84	43	84	14	0	25	1	1	

<sup>a/</sup> number of nets

Table G13. Sinking gill net catches (# fish/net) in the Canada area of Libby Reservoir by date.

Date	(N) <sup>a/</sup>	RB	WCT	HB	Total Trout	DV	KCK	MWF	CRC	NSQ	RSS	CSU	FSU
July 1983	(2)	0.00	0.00	0.00	0.00	0.50	0.00	0.50	9.50	1.00	0.00	7.50	0.00
Aug. 1983	(2)	1.00	1.00	0.00	2.00	0.00	0.00	2.00	9.50	5.50	0.50	20.00	0.50
Sep. 1983	(2)	0.50	0.00	0.50	1.00	0.50	1.50	7.00	7.50	3.50	0.50	4.50	0.10
Oct. 1983	(2)	1.50	0.00	1.00	2.50	0.50	0.50	5.50	2.50	3.00	0.50	8.00	0.50
Nov. 1983	(2)	2.00	0.00	0.00	2.00	1.50	0.00	11.50	5.00	2.00	0.00	1.50	0.00
1983 Total	(10)	1.00	0.20	0.30	1.50	0.60	0.40	5.30	8.80	3.00	0.30	8.30	0.30
Aug. 1984	(4)	0.50	0.50	0.00	1.00	0.50	1.25	4.00	13.30	2.80	0.25	7.30	0.00
Nov. 1984	(4)	0.50	0.75	0.75	2.00	0.00	1.50	11.25	0.75	1.00	0.00	2.25	0.25
1984 Total	(8)	0.50	0.62	0.38	1.50	0.25	1.38	7.62	0.20	1.88	0.13	4.75	0.12
Aug. 1985	(2)	0.50	0.00	0.00	0.50	0.00	1.00	7.00	7.50	1.00	0.00	2.50	0.00
Sep. 1987	(4)	3.75	0.00	0.25	4.00	0.00	21.00	10.75	21.00	3.50	0.00	6.25	0.25

<sup>a</sup> n=number of nets

APPENDIX H  
Tables H1 through H6

Limnetic zone vertical gill net catches  
in three areas of Libby Reservoir, 1983 through 1987.

Table H1. Vertical gill net catches of fish in the Tenmile area of Libby Reservoir by date.

Date	(N) <sup>a/</sup>	RB	WCT	HB	Total Trout	DV	RCK	MAF	CRG	NSQ	RSS	CSU	FSU
Oct. 1983	(16)	6	1	3	10	5	23	1	2	0	0	0	0
Dec. 1983	(8)	0	1	0	1	5	29	0	5	1	0	0	0
1983 TILS	(24)	6	2	3	11	10	52	1	7	1	0	0	0
Jan. 1984	(16)	7	0	1	8	6	108	0	12	0	0	0	0
Mar. 1984	(8)	0	0	0	0	1	51	0	11	0	0	0	0
Apr. 1984	(8)	3	0	0	3	1	81	0	11	0	0	0	0
May 1984	(8)	1	1	4	6	0	35	0	11	1	0	1	0
June 1984	(8)	0	0	2	2	3	54	0	2	1	0	1	0
July 1984	(16)	2	0	0	2	0	151	0	22	1	1	0	0
Aug. 1984	(8)	1	2	3	6	1	198	0	2	0	0	1	0
Oct. 1984	(8)	3	3	0	6	1	212	1	0	1	0	0	0
Nov. 1984	(8)	0	0	0	0	0	84	0	1	0	0	1	0
Dec. 1984	(8)	0	0	0	0	1	49	0	2	0	0	0	0
1984 TILS	(96)	17	6	10	33	14	1023	1	74	4	1	4	0
Jan. 1985	(8)	2	2	0	4	0	197	0	9	1	0	0	0
Apr. 1985	(4)	0	0	0	0	0	9	0	2	0	0	0	0
May 1985	(4)	0	0	0	0	0	114	0	38	0	0	0	0
June 1985	(4)	0	0	0	0	0	75	0	5	0	0	0	0
July 1985	(4)	0	1	0	1	0	114	0	2	0	0	0	0
Aug. 1985	(4)	0	5	1	6	0	197	0	14	0	0	0	0
Sep. 1985	(4)	0	1	1	2	1	16	0	2	0	0	1	0
Oct. 1985	(4)	2	0	0	2	0	8	0	0	0	0	0	0
1985 TILS	(36)	4	9	2	15	1	724	0	72	1	0	1	0
Jan. 1986	(4)	3	0	0	3	1	15	0	6	0	0	0	0
Apr. 1986	(4)	0	0	0	0	0	21	0	0	0	0	0	0
May 1986	(4)	0	0	0	0	1	18	1	13	0	0	0	0
June 1986	(4)	0	0	1	1	0	14	0	10	0	0	0	0
July 1986	(4)	0	1	0	1	0	29	0	6	0	0	0	0
Sep. 1986	(4)	0	0	0	0	0	76	0	1	0	0	1	0
Oct. 1986	(3)	0	0	0	0	0	118	0	0	0	0	0	0
Nov. 1986	(2)	0	0	0	0	0	45	0	2	0	0	0	0
Dec. 1986	(1)	0	0	0	0	2	35	0	0	0	0	0	0
1986 TILS	(30)	3	1	1	5	4	371	1	38	0	0	1	0
Mar. 1987	(1)	1	0	0	1	0	18	0	0	0	0	0	0
Apr. 1987	(1)	0	0	0	0	0	7	0	5	0	0	0	0
May 1987	(4)	0	0	1	1	0	42	1	19	0	0	0	0
June 1987	(2)	0	0	0	0	0	40	0	23	0	0	0	0
July 1987	(4)	0	1	2	3	2	54	0	13	1	0	1	0
Aug. 1987	(2)	0	0	1	1	0	39	0	40	0	0	0	0
Sep. 1987	(4)	0	0	0	0	1	207	0	12	0	0	0	0
Nov. 1987	(4)	0	0	0	0	0	72	0	1	1	0	0	0
1987 TILS	(22)	1	1	4	6	3	479	1	113	2	0	1	0

<sup>a/</sup> n=number of nets

Table H2. Vertical gill net catches of fish (# fish/net) in the Ternile area of Libby Reservoir by date.

Date	n <sup>a/</sup>	RB	WCT	HB	Total Trout	DV	KCK	MWF	CRC	NSQ	RSS	CSU	FSU
Oct. 1983	(16)	0.38	0.06	0.19	af.3	a31	1.44	0.06	0.13	0.00	0.00	0.00	0.00
Dec. 1983	(8)	0.00	0.13	0.00	0.13	a63	3.63	0.00	0.63	0.13	0.00	0.00	0.00
1983 TILS	(24)	0.25	0.08	0.13	0.46	0.42	2.17	0.04	0.29	0.04	0.00	0.00	a m
Jan. 1984	(16)	0.44	0.00	0.06	0.50	0.38	6.75	0.00	a75	a m	0.00	0.00	a m
Mar. 1984	(8)	0.00	0.00	0.00	0.00	0.13	6.38	0.00	1.38	0.00	0.00	0.00	0.00
Apr. 1984	(8)	0.38	0.00	0.00	0.38	0.13	10.13	0.00	1.38	0.00	0.00	0.00	0.00
May 1984	(8)	0.13	0.13	0.50	a75	0.00	4.38	0.00	1.38	0.13	0.00	0.13	a m
June 1984	(8)	0.00	0.00	0.25	0.25	0.38	6.75	0.00	0.25	0.13	0.00	0.13	0.00
July 1984	(16)	0.13	0.00	0.00	0.13	0.00	9.44	0.00	1.38	0.06	0.06	0.00	0.00
Aug. 1984	(8)	0.13	0.25	0.38	0.75	0.13	24.75	0.00	0.25	0.00	0.00	0.13	0.00
Oct. 1984	(8)	0.38	0.38	0.00	0.75	0.13	26.50	0.13	0.00	0.13	0.00	0.00	0.00
Nov. 1984	(8)	0.00	0.00	0.00	0.00	0.00	10.50	0.00	0.13	0.00	0.00	0.13	0.00
Dec. 1984	(8)	0.00	0.00	0.00	0.00	a u	6.13	0.00	0.25	0.00	0.00	0.00	0.00
1984 TILS	(96)	0.18	0.06	0.10	0.34	0.15	10.66	0.01	a77	0.04	0.01	0.04	0.00
Jan. 1985	(8)	0.25	0.25	0.00	0.50	0.00	24.63	0.00	1.13	0.13	0.00	0.00	a m
Apr. 1985	(4)	0.00	0.00	0.00	0.00	0.00	2.25	0.00	0.50	0.00	0.00	0.00	0.00
May 1985	(4)	a m	0.00	0.00	0.00	0.00	28.50	0.00	9.50	0.00	0.00	0.00	0.00
June 1985	(4)	0.00	0.00	0.00	0.00	0.00	18.75	0.00	1.25	0.00	0.00	0.00	0.00
July 1985	(4)	a m	0.25	0.00	0.25	0.00	28.50	0.00	0.50	0.00	0.00	a m	0.00
Aug. 1985	(4)	0.00	1.25	0.25	1.50	0.00	49.25	0.00	3.50	0.00	0.00	0.00	0.00
Sep. 1985	(4)	0.00	0.25	0.25	0.50	0.25	2.50	0.00	0.50	0.00	0.00	0.25	0.00
Oct. 1985	(4)	0.50	0.00	0.00	0.50	0.00	2.00	0.00	0.00	0.00	0.00	0.00	0.00
1985 TILS	(36)	a n	0.25	0.06	0.42	0.03	20.11	0.00	2.00	0.03	0.00	0.03	0.00
Jan. 1986	(4)	a75	0.00	0.00	a75	0.25	3.75	0.00	1.50	a m	0.00	a m	0.00
Apr. 1986	(4)	0.00	0.00	0.00	0.00	0.00	5.25	0.00	0.00	0.00	0.00	0.00	0.00
May 1986	(4)	0.00	0.00	0.00	0.00	0.25	4.50	0.25	3.25	0.00	0.00	0.00	0.00
June 1986	(4)	0.00	0.00	0.25	0.25	0.00	3.50	0.00	2.50	0.00	0.00	0.00	0.00
July 1986	(4)	0.00	0.25	0.00	0.25	0.00	7.25	0.00	1.50	0.00	0.00	0.00	a m
Sep. 1986	(4)	0.00	0.00	0.00	0.00	0.00	19.00	0.00	0.25	0.00	0.00	0.25	0.00
Oct. 1986	(3)	0.00	0.00	0.00	0.00	0.00	39.33	0.00	0.00	0.00	0.00	0.00	0.00
Nov. 1986	(2)	0.00	0.00	0.00	a m	0.00	22.50	0.00	1.00	0.00	0.00	0.00	0.00
Dec. 1986	(1)	0.00	0.00	0.00	0.00	2.00	35.00	0.00	0.00	0.00	0.00	0.00	0.00
1986 TILS	(30)	a m	0.03	0.03	a17	0.13	12.37	0.03	1.27	0.00	0.00	0.03	0.00
Mar. 1987	(1)	1.00	0.00	0.00	1.00	0.00	18.00	a m	0.00	0.00	a m	0.00	a m
Apr. 1987	(1)	0.00	0.00	0.00	0.00	0.00	7.00	a m	5.00	0.00	a m	0.00	0.00
May 1987	(4)	a m	0.00	0.25	0.25	0.00	10.50	0.25	4.75	0.00	0.00	0.00	0.00
June 1987	(2)	0.00	0.00	0.00	0.00	a m	20.00	0.00	11.50	0.00	0.00	0.00	0.00
July 1987	(4)	0.00	0.25	0.50	a75	0.50	13.50	0.00	3.25	0.25	0.00	0.25	0.00
Aug. 1987	(2)	0.00	0.00	0.50	0.50	0.00	19.50	0.00	20.00	0.00	0.00	0.00	0.00
Sep. 1987	(4)	0.00	0.00	0.00	0.00	0.25	51.75	0.00	3.00	0.00	0.00	0.00	0.00
Nov. 1987	(4)	0.00	0.00	0.00	0.00	0.00	18.00	0.00	0.25	0.25	0.00	0.00	0.00
1987 TILS	(22)	0.05	0.05	0.18	0.27	a14	21.77	0.05	5.14	0.09	0.00	0.05	0.00

a/ n=number of nets

Table H3. Vertical gill net catches of fish in the Rexford area of Libby Reservoir by date.

Date	(N) <sup>a/</sup>	RB	WCT	HB	Total Trout	DV	KOK	MAF	CRC	NSQ	RSS	CSU	FSU
Oct. 1983	(8)	2	2	0	4	4	1	0	6	3	0	0	0
Nov. 1983	(8)	0	0	0	0	1	2	0	3	2	0	0	0
Dec. 1983	(8)	0	0	0	0	0	15	0	1	4	0	0	0
1983 TILS	(24)	2	2	0	4	5	18	0	10	9	0	0	0
Jan. 1984	(8)	5	3	0	8	2	64	0	3	1	0	0	0
Feb. 1984	(8)	11	6	5	22	2	108	1	4	0	0	0	0
Mar. 1984	(8)	1	2	6	9	2	99	0	5	2	0	0	0
Apr. 1984	(8)	3	0	5	8	0	97	3	33	5	0	4	0
May 1984	(8)	7	0	1	8	4	205	0	16	5	0	4	0
June 1984	(8)	2	2	1	5	4	209	1	6	0	2	1	1
July 1984	(12)	2	1	0	3	2	134	4	25	0	0	0	0
Aug. 1984	(4)	1	2	0	2	1	84	0	1	0	0	1	0
Oct. 1984	(8)	3	1	0	4	2	215	0	20	1	0	0	0
Nov. 1984	(8)	0	0	1	1	0	109	0	1	2	0	0	0
Dec. 1984	(6)	0	0	0	0	2	71	0	0	2	0	0	0
1984 TILS	(86)	34	17	19	70	21	1395	9	114	18	2	10	1
Apr. 1985	(8)	4	1	2	7	3	146	0	168	4	0	0	0
May 1985	(4)	0	0	2	2	0	20	1	8	4	1	1	0
June 1985	(4)	0	0	0	0	0	53	0	4	0	0	0	0
July 1985	(4)	2	0	0	2	0	56	0	25	0	0	1	0
Aug. 1985	(4)	0	1	0	1	0	60	0	3	0	0	0	0
Sep. 1985	(4)	0	0	0	0	0	10	1	19	0	0	1	0
Oct. 1985	(4)	2	0	0	2	0	6	0	2	0	0	0	0
1985 TILS	(32)	8	2	4	14	3	351	2	229	8	1	3	0
Apr. 1986	(3)	3	0	0	3	1	14	0	38	2	0	2	0
May 1986	(4)	1	0	3	4	0	29	2	66	0	0	2	0
June 1986	(4)	0	0	2	2	0	14	5	15	0	0	0	0
July 1986	(8)	0	0	1	1	0	30	1	17	0	0	2	0
Aug. 1986	(4)	0	0	0	0	0	53	1	30	1	0	0	0
Oct. 1986	(8)	2	0	0	2	0	28	0	27	1	0	0	0
Nov. 1986	(4)	2	0	0	2	0	2	0	6	5	0	0	0
Dec. 1986	(4)	1	0	0	1	0	48	0	5	1	0	0	0
1986 TILS	(39)	9	0	6	15	1	218	9	204	10	0	6	0
Mar. 1987	(4)	0	1	0	1	0	37	0	33	0	0	0	0
Apr. 1987	(3)	1	0	0	1	0	56	0	83	0	0	0	0
May 1987	(4)	1	0	0	1	1	14	0	12	0	0	0	0
June 1987	(4)	0	0	0	0	0	88	0	4	0	0	0	0
July 1987	(4)	0	0	0	0	0	114	0	6	0	1	0	0
Aug. 1987	(4)	0	1	0	1	2	67	0	2	0	0	0	0
Sep. 1987	(4)	0	1	0	1	1	73	1	3	0	0	0	0
Nov. 1987	(4)	1	0	0	1	1	12	0	19	1	0	0	0
1987 TILS	(31)	3	3	0	6	5	461	1	162	1	1	0	0

<sup>a/</sup> number of nets

Table H4. Vertical gill net catches of fish (# fish/net) in the Rexford area of Libby Reservoir by date.

Date	(N) <sup>a/</sup>	RB	WCT	HB	Total Trout	DV	KOK	MWF	CRC	NSQ	RSS	CSU	FSU
Oct. 1983	(8)	0.25	0.25	0.00	0.50	0.50	0.13	0.00	0.75	0.38	0.00	0.00	0.00
Nov. 1983	(8)	0.00	0.00	0.00	0.00	0.13	0.25	0.00	0.38	0.25	0.00	0.00	0.00
Dec. 1983	(8)	0.00	0.00	0.00	0.00	0.00	1.88	0.00	0.13	0.50	0.00	0.00	0.00
1983 TILS	(24)	0.08	0.08	0.00	0.17	0.21	0.75	0.00	0.42	0.38	0.00	0.00	0.00
Jan. 1984	(8)	0.63	0.38	0.00	1.00	0.25	8.00	0.00	0.38	0.13	0.00	0.00	0.00
Feb. 1984	(8)	1.38	0.75	0.63	2.75	0.25	13.50	0.13	0.50	0.00	0.00	0.00	0.00
Mar. 1984	(8)	0.13	0.25	0.75	1.13	0.25	12.38	0.00	0.63	0.25	0.00	0.00	0.00
Apr. 1984	(8)	0.38	0.00	0.63	1.00	0.00	12.13	0.38	4.13	0.63	0.00	0.50	0.00
May 1984	(8)	0.88	0.00	0.13	1.00	0.50	25.63	0.00	2.00	0.63	0.00	0.50	0.00
June 1984	(8)	0.25	0.25	0.13	0.63	0.50	26.13	0.13	0.75	0.00	0.25	0.13	0.13
July 1984	(12)	0.17	0.08	0.00	0.25	0.17	11.17	0.33	2.08	0.00	0.00	0.00	0.00
Aug. 1984	(4)	0.00	0.50	0.00	0.50	0.25	21.00	0.00	0.25	0.00	0.00	0.25	0.00
Oct. 1984	(8)	0.38	0.13	0.00	0.50	0.25	26.88	0.00	2.50	0.13	0.00	0.00	0.00
Nov. 1984	(8)	0.00	0.00	0.13	0.13	0.00	13.63	0.00	0.13	0.25	0.00	0.00	0.00
Dec. 1984	(6)	0.00	0.00	0.00	0.00	0.33	11.83	0.00	0.00	0.33	0.00	0.00	0.00
1984 TILS	(86)	0.40	0.20	0.22	0.81	0.24	16.22	0.10	1.33	0.21	0.02	0.12	0.01
Apr. 1985	(8)	0.50	0.13	0.25	0.88	0.38	18.25	0.00	21.00	0.50	0.00	0.00	0.00
May 1985	(4)	0.00	0.00	0.50	0.50	0.00	5.00	0.25	2.00	1.00	0.25	0.25	0.00
June 1985	(4)	0.00	0.00	0.00	0.00	0.00	13.25	0.00	1.00	0.00	0.00	0.00	0.00
July 1985	(4)	0.50	0.00	0.00	0.50	0.00	14.00	0.00	6.25	0.00	0.00	0.25	0.00
Aug. 1985	(4)	0.00	0.25	0.00	0.25	0.00	15.00	0.00	0.75	0.00	0.00	0.00	0.00
Sep. 1985	(4)	0.00	0.00	0.00	0.00	0.00	2.50	0.25	4.75	0.00	0.00	0.25	0.00
Oct. 1985	(4)	0.50	0.00	0.00	0.50	0.00	1.50	0.00	0.50	0.00	0.00	0.00	0.00
1985 TILS	(32)	0.25	0.06	0.13	0.44	0.09	10.97	0.06	7.16	0.25	0.03	0.09	0.00
Apr. 1986	(3)	1.00	0.00	0.00	1.00	0.33	4.67	0.00	12.67	0.67	0.00	0.67	0.00
May 1986	(4)	0.25	0.00	0.75	1.00	0.00	7.25	0.50	16.50	0.00	0.00	0.50	0.00
June 1986	(4)	0.00	0.00	0.50	0.50	0.00	3.50	1.25	3.75	0.00	0.00	0.00	0.00
July 1986	(8)	0.00	0.00	0.13	0.13	0.00	3.75	0.13	2.13	0.00	0.00	0.25	0.00
Aug. 1986	(4)	0.00	0.00	0.00	0.00	0.00	13.25	0.25	7.50	0.25	0.00	0.00	0.00
Oct. 1986	(8)	0.25	0.00	0.00	0.25	0.00	3.50	0.00	3.38	0.13	0.00	0.00	0.00
Nov. 1986	(4)	0.50	0.00	0.00	0.50	0.00	0.50	0.00	1.50	1.25	0.00	0.00	0.00
Dec. 1986	(4)	0.25	0.00	0.00	0.25	0.00	12.00	0.00	1.25	0.25	0.00	0.00	0.00
1986 TILS	(39)	0.23	0.00	0.15	0.38	0.03	5.59	0.23	5.23	0.26	0.00	0.15	0.00
Mar. 1987	(4)	0.00	0.25	0.00	0.25	0.00	9.25	0.00	8.25	0.00	0.00	0.00	0.00
Apr. 1987	(3)	0.33	0.00	0.00	0.33	0.00	18.67	0.00	27.67	0.00	0.00	0.00	0.00
May 1987	(4)	0.25	0.00	0.00	0.25	0.25	3.50	0.00	3.00	0.00	0.00	0.00	0.00
June 1987	(4)	0.00	0.00	0.00	0.00	0.00	22.00	0.00	1.00	0.00	0.00	0.00	0.00
July 1987	(4)	0.00	0.00	0.00	0.00	0.00	28.50	0.00	1.50	0.00	0.25	0.00	0.00
Aug. 1987	(4)	0.00	0.25	0.00	0.25	0.50	16.75	0.00	0.50	0.00	0.00	0.00	0.00
Sep. 1987	(4)	0.00	0.25	0.00	0.25	0.25	18.25	0.25	0.75	0.00	0.00	0.00	0.00
Nov. 1987	(4)	0.25	0.00	0.00	0.25	0.25	3.00	0.00	4.75	0.25	0.00	0.00	0.00
1987 TILS	(31)	0.10	0.10	0.00	0.19	0.16	14.87	0.03	5.23	0.03	0.03	0.00	0.00

<sup>a/</sup> n=number of nets

Table H5. Vertical gill net catches of fish in the Canada area of Libby Reservoir by date.

Date	(N) <sup>a/</sup>	FB	WCT	HB	Total Trout	DV	KCK	MMF	CRG	NSQ	RSS	CSU	FSU
July 1984	(4)	1	0	0	1	0	2	2	15	1	0	11	2
Aug. 1984	(4)	0	0	1	1	0	1	0	12	7	0	0	0
Oct. 1984	(4)	0	0	0	0	0	6	0	1	1	0	0	0
1984 TILS	(12)	1	0	1	2	0	9	2	28	9	0	11	2
July 1985	(4)	0	0	0	0	0	4	0	16	2	1	0	0
Aug. 1985	(4)	0	0	0	0	1	7	0	86	5	0	0	0
Sep. 1985	(4)	1	1	0	2	0	20	0	3	2	1	0	0
Oct. 1985	(4)	0	0	0	0	0	7	0	0	0	0	0	0
1985 TILS	(16)	1	1	0	2	1	38	0	105	9	2	0	0
June 1986	(4)	0	0	1	1	0	0	1	61	1	0	3	1
July 1986	(4)	1	1	0	2	0	2	0	21	0	0	1	0
Aug. 1986	(4)	0	0	0	0	0	8	1	34	3	0	1	0
Sep. 1986	(4)	0	2	1	3	1	0	0	29	1	0	2	0
Oct. 1986	(4)	1	1	0	2	0	0	2	2	0	0	0	0
1986 TILS	(20)	2	4	2	8	1	10	4	147	5	0	7	1
June 1987	(4)	1	0	0	1	0	10	1	19	1	0	1	0
July 1987	(4)	1	0	0	1	0	7	0	86	2	0	0	0
Aug. 1987	(4)	1	2	1	4	0	8	2	112	3	0	0	0
Sep. 1987	(4)	2	1	0	3	0	2	0	26	6	0	0	0
Nov. 1987	(4)	0	0	0	0	0	0	0	0	0	1	0	0
1987 TILS	(20)	5	3	1	9	0	27	3	243	12	1	1	0

<sup>a/</sup> n=number of nets

Table H6. Vertical gill net catches of fish (# fish/net) in the Canada area of Libby Reservoir by date.

Date	(N) <sup>a/</sup>	RB	WCT	HB	Total Trout	DV	KOK	MAF	CRC	NSQ	RSS	CSU	FSU
July 1984	(4)	0.25	0.00	0.00	0.25	0.00	0.50	0.50	3.75	0.25	0.00	2.75	0.50
Aug. 1984	(4)	0.00	0.00	0.25	0.25	0.00	0.25	0.00	3.00	1.75	0.00	0.00	0.00
Oct. 1984	(4)	0.00	0.00	0.00	0.00	0.00	1.50	0.00	0.25	0.25	0.00	0.00	0.00
1984 TILS	(12)	0.08	0.00	0.08	0.17	0.00	0.75	0.17	2.33	0.75	0.00	0.92	0.17
July 1985	(4)	0.00	0.00	0.00	0.00	0.00	1.00	0.00	4.00	0.50	0.25	0.00	0.00
Aug. 1985	(4)	0.00	0.00	0.00	0.00	0.25	1.75	0.00	21.50	1.25	0.00	0.00	0.00
Sep. 1985	(4)	0.25	0.25	0.00	0.50	0.00	5.00	0.00	0.75	0.50	0.25	0.00	0.00
Oct. 1985	(4)	0.00	0.00	0.00	0.00	0.00	1.75	0.00	0.00	0.00	0.00	0.00	0.00
1985 TILS	(16)	0.06	0.06	0.00	0.13	0.06	2.38	0.00	6.56	0.56	0.13	0.00	0.00
June 1986	(4)	0.00	0.00	0.25	0.25	0.00	0.00	0.25	15.25	0.25	0.00	0.75	0.25
July 1986	(4)	0.25	0.25	0.00	0.50	0.00	0.50	0.00	5.25	0.00	0.00	0.25	0.00
Aug. 1986	(4)	0.00	0.00	0.00	0.00	0.00	2.00	0.25	8.50	0.75	0.00	0.25	0.00
Sep. 1986	(4)	0.00	0.50	0.25	0.75	0.25	0.00	0.00	7.25	0.25	0.00	0.50	0.00
Oct. 1986	(4)	0.25	0.25	0.00	0.50	0.00	0.00	0.50	0.50	0.00	0.00	0.00	0.00
1986 TILS	(20)	0.10	0.20	0.10	0.40	0.05	0.50	0.20	7.35	0.25	0.00	0.35	0.05
June 1987	(4)	0.25	0.00	0.00	0.25	0.00	2.50	0.25	4.75	0.25	0.00	0.25	0.00
July 1987	(4)	0.25	0.00	0.00	0.25	0.00	1.75	0.00	21.50	0.50	0.00	0.00	0.00
Aug. 1987	(4)	0.25	0.50	0.25	1.00	0.00	2.00	0.50	28.00	0.75	0.00	0.00	0.00
Sep. 1987	(4)	0.50	0.25	0.00	0.75	0.00	0.50	0.00	6.50	1.50	0.00	0.00	0.00
Nov. 1987	(4)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.00	0.00
1987 TILS	(20)	0.25	0.15	0.05	0.45	0.00	1.35	0.15	12.15	0.60	0.05	0.05	0.00

<sup>a/</sup> = number of nets

APPENDIX I  
Tables I1 through I4

Lengths and volumes at 10-m intervals for 38 hydroacoustic  
transects samples in Libby Reservoir during August,  
1984 through 1987.

Appendix II. Lengths and volumes at 10 m intervals for 38 hydroacoustic transects sampled in Libby Reservoir during August 1984<sup>a/</sup>.

Area Transect	Transect length (m)	Total volume by depth interval (m <sup>3</sup> x 100)						
		0-10	10-20	20-30	30-40	40-50	50-60	60-70
<u>Tennile</u>								
1	2024	177.1	531.3	885.5	1239.7	1593.9	1948.1	2302.3
2	1982	173.4	520.3	867.1	1214.0	1560.8	1907.7	2254.5
3	1966	172.0	516.1	860.1	1204.2	1548.2	1892.3	2236.3
4	2016	176.4	529.2	882.0	1234.8	1587.6	1940.4	2293.2
5	2212	193.6	580.6	967.8	1354.8	1742.0	2129.1	2516.2
6	2358	206.3	619.0	1031.6	1444.3	1856.9	2269.6	2682.2
7	2200	192.5	577.5	962.5	1347.5	1732.5	2117.5	2500.5
8	2205	192.9	578.8	964.7	1350.6	1736.4	2122.3	2508.2
9	2913	254.9	764.7	1274.4	1784.2	2294.0	2803.2	3313.5
10	1846	161.5	484.6	807.6	1130.7	1453.7	1776.8	2099.8
<u>Peck Gulch</u>								
11	1495	130.8	392.4	654.1	915.7	1117.3	1438.9	1700.6
12	1768	154.7	464.1	773.5	1082.9	1392.3	1701.7	2011.1
13	1457	127.5	382.5	637.4	892.4	1147.4	1402.4	1657.3
14	1724	150.8	452.6	754.2	1056.0	1357.7	1659.3	1961.0
15	2180	190.8	572.2	953.8	1335.2	1716.8	2098.2	2479.8
16	1888	165.2	495.6	826.0	1166.4	1486.8	1817.2	2147.6
17	1489	130.3	390.9	651.4	912.0	1172.6	1433.2	1693.7
18	754	66.0	197.9	329.9	461.8	593.8	725.7	857.7
19	1161	101.6	304.8	507.9	711.1	914.3	1117.5	1320.6
20	554	48.5	145.4	242.4	339.3	436.3	533.2	630.2
<u>Rexford</u>								
21	1850	161.9	485.6	809.4	1133.1	1456.9	1780.6	2104.4
22	728	63.7	191.1	318.5	445.9	573.3	700.7	828.1
23	2207	193.1	579.3	966.6	1351.8	1738.0	2124.2	2510.5
24	1518	132.8	398.5	664.1	929.8	1195.4	1461.1	1726.7
25	3056	267.4	802.2	1337.0	1871.8	2406.6	2941.4	3476.2
26	1943	170.0	510.0	850.1	1190.1	1530.1	1870.1	2210.2
27	1947	170.4	511.1	851.8	1192.5	1533.3	1874.0	2214.7
28	1619	141.7	425.0	708.3	991.6	1275.0	1558.3	1841.6
29	3315	290.1	870.2	1450.3	2030.4	2610.6	3190.7	3770.8
30	3441	301.1	903.3	1505.4	2107.6	2709.8	3312.0	3914.1
<u>Canada</u>								
31	1023	89.5	268.5	447.6	626.6	806.6	984.6	1163.7
32	1159	101.4	304.2	507.1	709.9	912.7	1115.5	1318.4
33	2541	222.3	667.0	1111.7	1556.4	2001.0	2445.7	2890.4
34	3439	300.9	902.7	1504.6	2106.4	2708.2	3310.1	3911.9
35	909	79.5	238.6	397.7	556.8	715.8	874.9	1034.0
36	3661	320.3	961.0	1601.7	2242.4	2883.0	3523.7	4184.4
37	3203	280.3	840.8	1401.3	1961.8	2522.4	3082.9	3643.4
38	2094	183.2	549.7	916.1	1282.6	1649.0	2015.5	2381.9
Total	75.8 km							

<sup>a/</sup> Areas (m<sup>2</sup>) for acoustic cones at selected depths are 8.75 at 10 m, 26.25 at 20 m, 43.75 at 30 m, 61.25 at 40 m, 78.75 at 50 m, 96.25 at 60 m, 113.75 at 70 m.

Appendix I2. Lengths and volumes at 10 m intervals for 38 hydroacoustic transects sampled in Libby Reservoir during August 1985<sup>a/</sup>.

Area Transect	Transect length (m)	Total volume by depth interval (m <sup>3</sup> x 100)						
		0-10	10-20	20-30	30-40	40-50	50-60	60-70
<u>Tennile</u>								
1	1814	158.7	476.2	793.6	1111.1	1428.5	1746.0	x63.4
2	2129	186.3	558.9	931.4	1304.0	1676.6	2049.2	2421.7
3	1610	140.9	422.6	704.4	986.1	1267.9	1549.6	1831.4
4	1740	152.2	456.8	761.2	1065.8	1370.2	1674.8	1979.2
5	1944	170.1	510.3	850.5	1190.7	1530.9	1871.1	2211.3
6	1907	166.9	500.6	834.3	1168.0	EQ1.8	1835.5	2169.2
7	2147	x37.9	563.6	939.3	1315.0	1690.8	xE6.5	2442.2
8	1962	171.7	515.0	858.4	1201.7	1545.1	1888.4	2231.8
9	2369	207.3	621.9	1036.4	1451.0	1865.6	2280.2	2694.7
10	1851	162.0	485.9	809.8	1133.7	1457.7	1781.6	2105.5
<u>Peck Gulch</u>								
11	1499	131.2	393.5	655.8	918.1	1180.5	1442.8	1705.1
12	1536	134.4	403.2	672.0	940.8	1209.6	1478.4	1747.2
13	1092	95.5	286.6	477.8	668.9	860.0	1051.0	1242.2
14	1407	123.1	369.3	615.6	861.8	1108.0	1354.2	1600.5
15	2036	178.2	534.5	890.8	1247.0	1603.3	1959.7	2315.9
16	1777	155.5	466.5	777.4	1088.4	1399.4	1710.4	2021.3
17	1666	145.8	437.3	728.9	1020.4	1312.0	1603.5	1895.1
18	740	644.8	194.2	323.8	453.2	582.8	712.2	841.8
19	907	79.4	238.1	396.8	555.5	714.3	873.0	1031.7
20	555	48.6	145.7	242.8	339.9	437.1	534.2	631.3
<u>Rexford</u>								
21	888	77.7	233.1	388.5	543.9	689.3	854.7	1010.1
22	814	71.2	213.7	356.1	498.6	641.0	783.5	925.9
23	3443	301.3	903.8	1506.3	2108.8	2711.4	3313.9	3916.4
24	1388	121.5	364.4	607.2	850.1	1093.0	1336.0	E78.8
25	3239	283.4	850.2	1417.1	1983.9	2550.7	3117.5	3684.4
26	1870	163.6	490.9	818.1	1145.4	1472.6	1799.9	2127.1
27	1851	162.0	485.9	809.8	1133.7	1457.7	1781.6	2105.5
28	1999	174.9	524.7	874.6	1224.4	1574.2	1924.0	2273.9
29	3276	286.6	860.0	1433.2	2006.5	2579.8	3153.2	3726.4
30	3665	320.7	962.1	16u3.4	2244.8	2886.2	3527.6	4168.9
<u>Canada</u>								
31	926	81.0	243.1	405.1	567.2	729.2	891.3	1053.3
32	1333	116.6	349.9	583.2	816.5	1049.7	1283.0	1516.3
33	2591	226.7	680.1	U33.6	1587.0	2040.4	2493.8	2947.3
34	1814	158.7	476.2	793.6	1111.1	1428.5	1746.0	2063.4
35	1333	116.6	349.9	583.2	816.5	1049.7	1283.0	1516.3
36	4702	411.4	1234.3	2057.1	2880.0	37CQ.8	4525.7	5348.5
37	2332	204.1	612.1	1020.2	1428.3	1836.5	2244.6	2652.7
38	2776	242.9	728.7	1214.5	1700.3	2186.1	2671.9	3E7.7
Total	72.9 km							

<sup>a/</sup> Areas (m<sup>2</sup>) for acoustic cones at selected depths are 8.75 at 10 m, 26.25 at 20 m, 43.75 at 30 m, 61.25 at 40 m, 78.75 at 50 m, 96.25 at 60 m, 113.75 at 70 m.

Appendix I3. Lengths and volumes at 10 m intervals for 38 hydroacoustic transects sampled in Libby Reservoir during August 1986<sup>a/</sup>.

Area Transect	Transect length (m)	Total volume by depth interval (m <sup>3</sup> x 100)						
		0-10	10-20	20-30	30-40	40-50	50-60	60-70
<u>Tennile</u>								
1	3313	289.9	869.7	1449.4	2029.2	2609.0	3188.8	3768.5
2	2258	197.6	592.7	987.9	1383.0	1778.2	2173.3	2568.5
3	1740	152.2	456.8	700.2	10815.8	1370.2	1674.8	1979.2
4	2203	192.8	578.3	963.8	1349.3	1734.9	2120.4	2505.9
5	1684	147.3	442.1	736.8	1031.5	1326.2	1620.8	1915.5
6	2721	238.1	714.3	1190.4	1666.6	2142.8	2619.0	3095.1
7	3313	289.9	869.7	1449.4	2029.2	2609.0	3188.8	3768.5
8	4535	396.8	3390.4	1984.1	2777.7	3571.3	4364.9	5158.6
9	1647	144.1	432.3	720.6	1008.8	1297.0	1585.2	1873.5
10	2314	202.5	607.4	1012.4	1417.3	1822.3	2227.2	2632.2
<u>Peck Gulch</u>								
11	1703	149.0	447.0	745.1	1043.1	1341.1	1639.1	1937.2
12	3424	299.6	898.8	1498.0	2097.2	2696.4	3295.6	3894.8
13	1610	140.9	422.6	704.4	986.1	1267.9	1549.6	1831.4
14	1888	165.2	495.6	826.0	1156.4	1486.8	1817.2	2147.6
15	2221	194.3	583.0	971.7	1360.4	1749.0	2137.7	2526.4
16	2036	178.2	534.5	890.8	1247.0	1603.3	1959.7	2315.9
17	2369	207.3	621.9	1036.4	1451.0	1865.6	2280.2	2694.7
18	1185	103.7	311.1	518.4	725.8	933.2	1140.6	1347.9
19	981	85.8	257.5	429.2	600.9	772.5	944.2	1150.9
20	666	58.3	174.8	291.4	400.9	524.5	641.0	757.6
<u>Rexford</u>								
21	2665	233.2	689.6	1165.9	1632.3	2098.7	2565.1	3031.4
22	1259	110.2	330.5	550.8	771.1	991.5	1211.8	1432.1
23	2925	255.9	767.8	1279.7	1791.6	2303.4	2815.3	3327.2
24	1703	149.0	447.0	745.1	1043.1	1341.1	1639.1	1937.2
25	5146	450.3	1350.8	2251.4	3151.9	4052.5	4953.0	5853.6
26	2295	200.8	602.4	1004.1	1405.7	1807.3	2208.9	2610.6
27	2147	187.9	563.6	939.3	1315.0	1690.8	2066.5	2442.2
28	1925	168.4	505.3	842.2	1079.1	1515.9	1852.8	2189.7
29	3850	336.9	1010.6	1684.4	2358.1	3031.9	3705.6	4379.4
30	3887	340.1	1020.3	1700.6	2380.8	3061.0	3741.2	4421.5
<u>Canada</u>								
31	1055	92.3	276.9	461.6	646.2	830.8	1015.4	1200.1
32	1259	110.2	330.5	550.8	771.1	991.5	1211.8	1432.1
33	2739	239.7	719.0	1198.3	1677.6	2157.0	2636.3	3115.6
34	3832	335.3	1005.9	1676.5	2347.1	3017.7	3688.3	4358.9
35	1018	89.1	267.2	445.4	623.5	801.7	979.8	1158.0
36	3683	322.3	966.8	1611.3	2255.8	2900.4	3544.9	4189.4
37	3184	278.6	835.8	1393.0	1950.2	2507.4	3064.6	3621.8
38	2166	189.5	568.6	947.6	1326.7	1705.7	2084.8	2463.8
Total	90.5 km							

<sup>a/</sup> Areas (m<sup>2</sup>) for acoustic cones at selected depths are 8.75 at 10 m, 26.25 at 20 m, 43.75 at 30 m, 61.25 at 40 m, 78.75 at 50 m, 96.25 at 60 m, 113.75 at 70 m.

Appendix I4. Lengths and volumes at 10 m intervals for 38 hydroacoustic transects sampled in Libby Reservoir during August 1987<sup>a/</sup>.

Area Transect	Transect length (m)	Total volume by depth interval (m <sup>3</sup> x 100)						
		0-10	10-20	20-30	30-40	40-50	50-60	60-70
<u>Tennile</u>								
1	2203	192.8	578.3	963.8	1349.3	1734.9	2120.4	2505.9
2	2573	225.1	675.4	u25.7	1576.0	2ax.2	2476.5	2926.8
3	1777	155.5	466.5	m . 4	1088.4	1399.4	1710.4	2021.3
4	2240	196.0	588.0	980.0	1372.0	1764.0	2156.0	2548.0
5	2036	178.2	534.5	890.8	1247.0	1603.3	1959.7	2315.9
6	1814	158.7	476.2	793.6	1111.1	1428.5	1746.0	2063.4
7	2110	184.6	553.9	923.1	1292.4	1661.6	2030.9	2400.1
8	2073	x31.4	544.2	905.9	1269.7	1632.5	1995.3	2358.0
9	3091	270.5	811.4	1352.3	1893.2	2434.2	2975.1	3516.0
10	2055	179.8	539.4	899.1	1258.7	1618.3	1977.9	2337.6
<u>Peck Gulch</u>								
11	1055	92.3	276.9	461.6	646.2	830.8	1015.4	1200.1
12	2277	199.2	597.7	996.2	1394.7	1793.1	2191.6	2590.1
13	1111	97.2	291.6	486.1	680.5	874.9	1069.3	1263.8
14	1592	139.3	417.9	696.5	975.1	1253.7	Ei32.3	1810.9
15	1647	144.1	432.3	720.6	1008.8	1297.0	1585.2	1873.5
16	1555	136.1	4cB.2	680.3	952.4	1224.6	1496.7	1768.8
17	2110	184.6	553.9	923.1	1292.4	1661.6	2iBo.9	2400.1
18	1000	87.5	262.5	437.5	612.5	787.5	962.5	u37.5
19	833	72.9	218.7	364.4	510.2	656.0	801.8	947.5
20	555	48.6	145.7	242.8	339.9	437.1	534.2	631.3
<u>Rexford</u>								
21	1629	142.5	427.6	712.7	937.8	1282.8	1567.9	1853.0
22	1277	111.7	335.2	558.7	782.2	1006.6	1229.1	1452.6
23	2406	210.5	631.6	10E2.6	1473.7	1894.7	2315.8	2736.8
24	1555	136.1	408.2	680.3	952.4	1224.6	1496.7	1768.8
25	2851	249.5	748.4	1247.3	1746.2	2245.2	2744.1	3243.0
26	2184	191.1	m . 3	955.5	1337.7	1719.9	2102.1	2484.3
27	1684	147.3	442.1	736.8	1a31.5	1326.2	1620.8	1915.5
28	1721	150.6	451.8	752.9	1054.1	1355.3	1656.5	1957.6
29	3128	273.7	821.1	1368.5	1915.9	2463.3	3010.7	3568.1
30	3332	291.6	874.6	1457.8	2040.8	2623.9	3207.1	3790.2
<u>Canada</u>								
31	981	85.8	257.5	429.2	600.9	772.5	944.2	1115.9
32	777	68.0	204.0	339.9	475.9	611.9	747.9	883.8
33	2351	205.7	617.1	1028.6	1440.0	1851.4	2262.8	2674.3
34	3276	286.6	860.0	1433.2	2006.5	2579.8	3153.2	3726.4
35	833	72.9	218.7	364.4	510.2	656.0	801.8	947.5
36	3887	340.1	1020.3	1700.6	2380.8	3061.0	3741.2	4421.5
37	1314	115.0	344.9	574.9	804.8	1034.8	1264.7	1494.7
38	3721	325.6	976.8	1627.9	2279.1	2930.3	3581.5	4232.6
Total	74.6 km							

<sup>a/</sup> Areas (m<sup>2</sup>) for acoustic cones at selected depths are 8.75 at 10 m, 26.25 at 20 m, 43.75 at 30 m, 61.25 at 40 m, 78.75 at 50 m, 96.25 at 60 m, 113.75 at 70 m.